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Best Demonstrated Available Technology (BDAT) Background Document for Wastes from the Production of Dinitrotoluene, Toluenediamine, and Toluene Diisocyanate (K027, K111, K112, K113, K114, K115, K116, U221, and U223)

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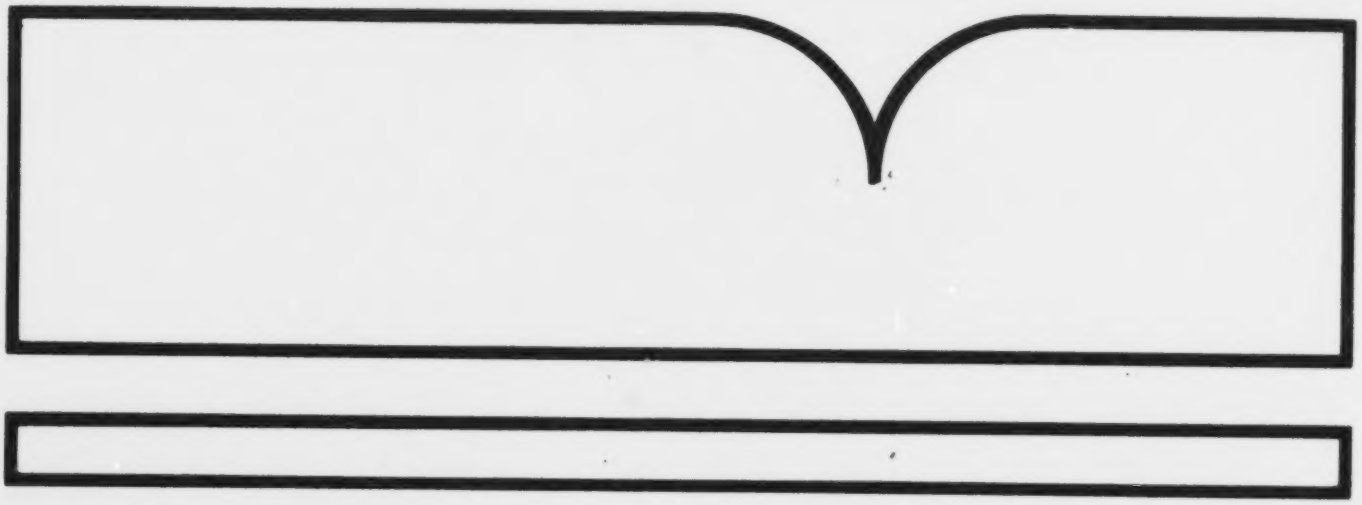

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FINAL

BEST DEMONSTRATED AVAILABLE TECHNOLOGY (BDAT)

BACKGROUND DOCUMENT

FOR WASTES FROM THE PRODUCTION OF

DINITROTOLUENE, TOLUENEDIAMINE, AND TOLUENE DIISOCYANATE

K027, K111, K112, K113, K114, K115, K116, U221, and U223

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This background document provides the Agency's treatment standards for wastes from the production of dinitrotoluene, toluenediamine, and toluene diisocyanate (K027, K113-K116, U221, and U223). The Agency is not proposing treatment standards for the newly listed wastes K111 and K112 at this time. This background document presents waste-specific information--the number and locations of facilities affected by the land disposal restrictions for K027, K113-K116, U221 and U223 wastes, the waste generating process, characterization data, and the technologies used to treat the waste or similar wastes. This document also explains the determination of BDAT, selection of constituents to be regulated, and calculation of treatment standards.

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EXECUTIVE SUMMARY

BDAT Treatment Standards for K027, K113, K114, K115, K116, U221, and U223

Pursuant to section 3004(m) of the Hazardous and Solid Waste Amendments (HSWA) enacted on November 8, 1984, the Environmental Protection Agency (EPA) is establishing best demonstrated available technology (BDAT) treatment standards for the listed wastes identified in 40 CFR 261.32 and 40 CFR 261.33 as K027, K113, K114, K115, K116, U221, and U223. Compliance with these BDAT treatment standards is a prerequisite for placement of these wastes in units designated as land disposal units according to 40 CFR Part 268. The effective date of these treatment standards is June 8, 1989.

The background document provides the Agency's treatment standards for K027, K113-K116, U221, and U223. The Agency is not proposing treatment standards for the newly listed wastes K111 and K112 at this time.

The EPA pamphlet entitled Methodology for Developing BDAT Treatment Standards summarized the Agency's legal authority and promulgated methodology for establishing treatment standards. The background document presents waste-specific information -- the number and locations of facilities affected by the land disposal restrictions for K027, K113-K116, U221, and U223 wastes, the waste generating process, characterization data, and the technologies used to treat the waste (or similar wastes). The document also explains EPA's

determination of BDAT, selection of constituents to be regulated, and calculation of treatment standards.

According to 40 CFR 261.32 and 40 CFR 261.33, waste codes K027, K111-K116, U221, and U223, which are generated by the production of dinitrotoluene (DNT), toluenediamine (TDA), and toluene diisocyanate (TDI) are listed as follows:

K027	Centrifuge and distillation residues from toluene diisocyanate production.
K111	Product washwaters from the production of dinitrotoluene via nitration of toluene.
K112	Reaction by-product water from the drying column in the production of toluenediamine via hydrogenation of dinitroluene.
K113	Condensed liquid light ends from the production of toluenediamine via hydrogenation of dinitroluene.
K114	Vicinals from the purification of toluenediamine in the production of toluenediamine via hydrogenation of dinitrotoluene.
K115	Heavy ends from the purification of toluenediamine in the production of toluenediamine via hydrogenation of dinitrotoluene.
K116	Organic condensate from the solvent recovery column in the production of toluene diisocyanate via phosgenation of toluenediamine.
U221	Toluenediamine (TDA)
U223	Toluene diisocyanate (TDI)

EPA has estimated that eight domestic facilities that produce DNT, TDA, and TDI are potential generators of the K027, K111-K116, U221 and U223 wastes. In addition, U221 and U223 wastes may be generated by users of TDA and TDI.

Treatment standards are established for both nonwastewater and wastewater forms of K027, K113-K116, U221, and U223. For the purpose of determining the applicability of the treatment standards, wastewaters for

K027, K113-K116, U221, and U223 are designed as wastes containing less than 1 percent (weight basis) total suspended solids[1] and less than 4 percent (weight basis) total organic carbon (TOC). Wastes not meeting this definition must comply with the treatment standards for nonwastewaters.

For K027, K113-K116, U221, and U223 nonwastewaters, the Agency is establishing a technology treatment standard of either incineration or fuel substitution. In addition, a treatment standard is established for nickel in K115 based on stabilization.

For K027, K113-K116, U221, and U223 wastewaters, the Agency is establishing a technology treatment standard of either carbon adsorption followed by regeneration or incineration of spent carbon or incineration. In addition, a treatment standard is established for nickel in K115 based on lime and suffide precipitation followed by vacuum filtration.

The following tables present the treatment standards for K027, K113-K116, U221, and U223 wastes. The treatment standards are specified technologies for organics in wastewater and nonwastewater forms of the wastes and a numerical treatment standard for nickel in wastewater and nonwastewater

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[1]The term "total suspended solids" (TSS) clarifies EPA's previously used terminology of "total solids" and "filterable solids". Specifically, total suspended solids is measured by method 209C (total suspended solids dried at 103-105°C) in Standard Methods For The Examination Of Water and Wastewater, 16th edition.

forms of K115. The numerical standards are TCLP for nonwastewater forms of K115 and total composition for wastewater forms of K115. The units are mg/kg (parts per million on a weight-by-weight basis) for nonwastewater and mg/l (parts per million on a weight-by-volume basis) for wastewater. K027, K113-K116, U221, and U223 wastes must be treated by the promulgated BDAT as a prerequisite to land disposal.

1.0 INTRODUCTION

1.1 Background

The Hazardous and Solid Waste Amendments Act (HSWA), enacted on November 8, 1984, amended the Resource Conservation and Recovery Act (RCRA) of 1976. Pursuant to HSWA, Section 3004(g) of RCRA requires the U.S. Environmental Protection Agency (EPA) to promulgate regulations that restrict the land disposal of hazardous wastes beyond specified dates. Under Section 3004(m) of RCRA, the Agency is required to set "levels or methods of treatment, if any, which substantially reduce the likelihood of migration of hazardous constituents from the waste so that short-term and long-term threats to human health and the environment are minimized." As specified in the promulgated regulatory framework for implementing the land disposal restrictions, these "treatment standards" are based on the performance of the best demonstrated available technologies (BDAT) for a waste. If a waste or treatment residual, as generated or treated, meets the BDAT treatment standard established by EPA for that waste, then the prohibition on land disposal does not apply and the waste may be land disposed.

HSWA requires EPA to establish treatment standards for all listed hazardous wastes according to the following schedule:

DATE	GOAL
August 8, 1988	Treatment standards for at least one-third of all listed hazardous wastes

K027, which is generated from the production of toluene diisocyanate (TDI), is part of the second-third of the scheduled listed wastes to be evaluated by the Agency for land disposal restrictions. Wastes listed as K111, K112, K113, K114, K115, and K116, which are generated from the production of dinitrotoluene (DNT), toluenediamine (TDA), or toluene diisocyanate (TDI), are "newly listed" (i.e., listed as hazardous wastes after November 8, 1984). Treatment standards for K113-K116 are being promulgated as part of this second-thirds rulemaking. The Agency is not promulgating treatment standards for the newly listed wastes K111 and K112 at this time. In addition, the Agency is promulgating treatment standards for soft-hammered first-third U wastes, U221 and U223. These wastes are generated from spills, leaks, or discard of chemicals associated with the production of TDA and TDI or from the use of TDA or TDI as active or additive ingredients in manufacturing processes. Treatment standards are also being promulgated for K027-, K113-K116-, U221-, and U223-containing wastewaters generated from RCRA corrective actions and CERCLA remedial orders (as either contaminated ground or surface water).

Wherever EPA believes that wastes represented by different codes can be treated to similar concentrations using identical technologies, the Agency has combined the codes into one treatability group (53 FR 31145, August 17, 1988). Based on a review of waste generation data, waste management practices, and waste characterization data for the wastes, EPA believes that these wastes can be combined into two waste treatability groups: (1) the K027, K113-K116, U221, and U223 treatability group (hereafter referred to as the "K027 treatability group"), and (2) the K111 and K112 treatability group.

EPA may establish treatment standards either as a specific treatment technology or as a performance level of treatment monitored by measuring the concentration levels of the hazardous constituents in the waste, treatment residual, or extract of the waste. While EPA prefers to establish treatment standards as performance levels, this approach is not always possible. As discussed in this background document, EPA is promulgating BDAT treatment standards for K027, K113, K114, K115, K116, U221, and U223 (the K027 treatability group) as specific treatment technologies. For the K115 waste code, EPA is also promulgating performance level treatment standards for nickel in wastewaters and nonwastewaters, since this BDAT List metal constituent is present at treatable concentrations in the waste, and treatment performance data are available for this constituent.

The Agency's decision to establish treatment standards as specific treatment technologies for the K027 treatability group (except nickel in K115, which is being promulgated at a concentration level in the treatment residual) is based on the following rationale. EPA does not currently have any treatment performance data for any of the wastes in the K027 treatability group. The Agency has not pursued treatment performance testing for these wastes because EPA has determined that available analytical methods cannot satisfactorily measure the principal hazardous organic constituents (aromatic rings containing nitrogen compounds) contained in K027, K113-K116, U221, and U223 wastes and treatment residuals. In addition, the Agency currently has not identified any organic constituents in these wastes that could be used as surrogates or indicator constituents in order to develop alternative numerical

standards for these wastes. Therefore, the Agency is unable to develop concentration-based BDAT treatment standards for these wastes at this time.

Instead, the Agency is promulgating treatment standards for the organic hazardous constituents expressed as specific methods of treatment. For the nonwastewater forms of K027, K113-K116, U221, and U223, the treatment methods are either incineration or fuel substitution. Incinerators must comply with the requirements of 40 CFR 264 Subpart O, or 265 Subpart O. Fuel substitution units must comply with the requirements of 40 CFR Part 266, Subpart D. For the wastewater forms of K027, K113-K116, U221, and U223, the methods are either carbon adsorption followed by incineration of spent carbon, or direct incineration of the wastewaters. It should be noted that the use of other treatment technologies prior to carbon adsorption is not prohibited by this rule. In addition, for K115 wastes, the Agency is promulgating concentration-based treatment standards for nickel. Since EPA is specifying a treatment method as the treatment standard, residues resulting from the required treatment method are no longer prohibited from land disposal (unless EPA should otherwise specify other requirements as it is doing for nickel in K115 and for organics concentrated in the spent carbon from the treatment of K027 group wastewaters). In addition, any nonwastewater residues from treatment technologies prior to carbon adsorption must meet the same treatment standards applicable to the spent carbon (i.e., incineration). The wastewater effluent from carbon adsorption is considered to meet the treatment standard.

In order to specify a method of treatment for a waste, EPA must show that the technology is BDAT for that waste. For a technology to be considered BDAT, it must provide substantial treatment of the constituents of concern, similar constituents, or constituents that are harder to treat than the constituents of concern. In the absence of treatment performance data, EPA may show that a technology provides substantial treatment for similar wastes that are believed to be more difficult to treat than K027, K113-K116, U221, and U223. This background document presents EPA's documentation that the demonstrated and required treatment technologies (incineration or fuel substitution for nonwastewaters and carbon adsorption or incineration for wastewaters) provide substantial treatment of hazardous constituents in the K027 treatability group, based on a review of treatment performance data for other wastes.

The Agency is not promulgating BDAT treatment standards for the newly listed wastes K111 and K112 at this time. As is the case for wastes in the K027 treatability group, EPA does not have any treatment performance data for K111 or K112, and the Agency has determined that available analytical methods cannot satisfactorily measure the principal hazardous organic constituents (aromatic rings containing nitrogen compounds) contained in K111 and K112 wastes and treatment residuals. Since these wastes were listed after the enactment of HSWA, land disposal of these wastes is not subject to either the "soft hammer" provisions or the May 8, 1990 "hard hammer" provisions. Consequently, land disposal of K111 and K112 may continue until regulations restrict their disposal.

Additional information on the Agency's legal authority and promulgated methodology for establishing treatment standards, and the petition process necessary for requesting a variance from the treatment standards, is provided in the EPA pamphlet Methodology for Developing BDAT Treatment Standards(8).

1.3 Organization of Background Document

Section 2.0 of this document presents information on the industry affected by the land disposal restrictions and on waste characterization data available for K027 and K111-K116. A more detailed discussion is also provided for the determination of waste treatability groups identified for the K027, K111-K116, U221, and U223 waste codes. Section 3.0 presents the applicable and demonstrated treatment technologies for the treatability groups, while Section 4.0 presents treatment performance data used in determining BDAT for the treatability groups. (As discussed above, treatment performance data are not available for use in determining BDAT for the K111 and K112 treatability group.) Section 5.0 explains EPA's determination of BDAT for the treatability groups. Section 6.0 discusses the selection of nickel for regulation in K115, and Section 7.0 explains the calculation of the treatment standard for nickel in K115.

BDAT Treatment Standards
for K027, K113-K116, U221 and U223
(Nonwastewaters)

EITHER INCINERATION OR FUEL SUBSTITUTION* AS A METHOD OF TREATMENT

* - Incinerators must comply with 40 CFR 264 Subpart O or 265 Subpart O. Fuel substitution units must be in compliance with 40 CFR Part 266 Subpart D.

BDAT Treatment Standards
for K027, K113-K116, U221 and U223
(Wastewaters)

CARBON** ADSORPTION OR INCINERATION* AS A METHOD OF TREATMENT

* - Incinerators must comply with 40 CFR 264 Subpart O or 265 Subpart O. Fuel substitution units must be in compliance with 40 CFR Part 266 Subpart D.

** - Spent carbon and any other nonwastewater residuals generated upstream from a carbon adsorption unit must meet the nonwastewater standards applicable to these wastes prior to land disposal. Carbon adsorption units must be operated such that breakthrough of TDI and TDA does not occur. Selection of a surrogate or indicator compound as a measure of breakthrough should be considered on a case-by-case situation.

BDAT Treatment Standards for K115
(Nonwastewaters)

Constituent	Maximum For Any Single Grab Sample Total Composition (mg/kg)	TCLP (mg/l)
Nickel	Not Applicable	0.32

BDAT Treatment Standards for K115
(Wastewaters)

Constituent	Maximum For Any Single Grab Sample Total Composition (mg/l)	TCLP (mg/l)
Nickel	0.47	Not Applicable

2.0 INDUSTRY AFFECTED AND WASTE CHARACTERIZATION

The purpose of this section is to describe the industry affected by the land disposal restrictions for K027, K111, K112, K113, K114, K115, K116, U221, and U223 and to present available characterization data for these wastes.

Wastes identified as K027, K111, K112, K113, K114, K115, K116, U221, and U223 are specifically generated by dinitrotoluene (DNT), toluenediamine (TDA), and toluene diisocyanate (TDI) manufacturing processes and are listed in 40 CFR 261.32 and 261.33(f) as follows:

Waste Code	Listed Waste
K027	Centrifuge and distillation residues from toluene diisocyanate production
K111	Product washwaters from the production of dinitrotoluene via nitration of toluene
K112	Reaction by-product water from the drying column in the production of toluenediamine via hydrogenation of dinitrotoluene
K113	Condensed liquid light ends from the production of toluenediamine via hydrogenation of dinitrotoluene
K114	Vicinals[1] from the purification of toluenediamine in the production of toluenediamine via hydrogenation of dinitrotoluene

[1]Vicinals are the ortho isomers of TDA. Ortho isomers are removed before phosgenation of TDA to TDI to avoid the formation of methylbenzimidazolone which reduces the reaction yield.

Waste Code	Listed Waste
K115	Heavy ends from the purification of toluenediamine in the production of toluenediamine via hydrogenation of dinitrotoluene
K116	Organic condensate from the solvent recovery column in the production of toluene diisocyanate via phosgenation of toluenediamine
U221	Toluenediamine
U223	Toluene diisocyanate

2.1 Industry Affected and Process Description

The Agency estimates that there are eight domestic facilities that produce dinitrotoluene (DNT), toluenediamine (TDA), and/or toluene diisocyanate (TDI). The majority of these facilities are located in the southern and eastern sections of the United States. Table 2-1 lists the number of facilities manufacturing each product, along with potential wastes generated, by state and EPA region. A simplified flow diagram illustrating the manufacturing processes generating dinitrotoluene, toluenediamine, and toluene diisocyanate is presented in Figure 2-1. DNT and TDA are generally produced for use in TDI manufacturing. Additionally, TDA may be produced for use in the manufacture of dyes or other chemical products; however, the production level of TDA for these purposes is believed to be quite low. Almost all of the TDI produced is used to manufacture polyurethanes, including polyurethane foam products, coatings, elastomers, and adhesives.

Table 2-1

FACILITIES THAT MAY GENERATE K027, K111, K112, K113, K114, K115, AND/OR K116, BY STATE AND EPA REGION*

State (EPA Region)	Number of Facilities			Wastes Potentially Generated
	DNT	TDA	TDI	
Louisiana (VI)	1	3	3	K027, K111, K112, K113, K114, K115, K116
New Jersey (II)	1	0	0	K111
Texas (VI)	2	2	2	K027, K111, K112, K113 K114, K115, K116
West Virginia (III)	1	1	1	K027, K111, K112, K115, K116

DNT = Dinitrotoluene
TDA = Toluenediamine
TDI = Toluene Diisocyanate

*Any facility generating TDA and TDI might also generate U221 and U223 wastes. See reference 21.

Source: Telephone Survey conducted in July 1988 by Radian Corporation, Herndon, VA.

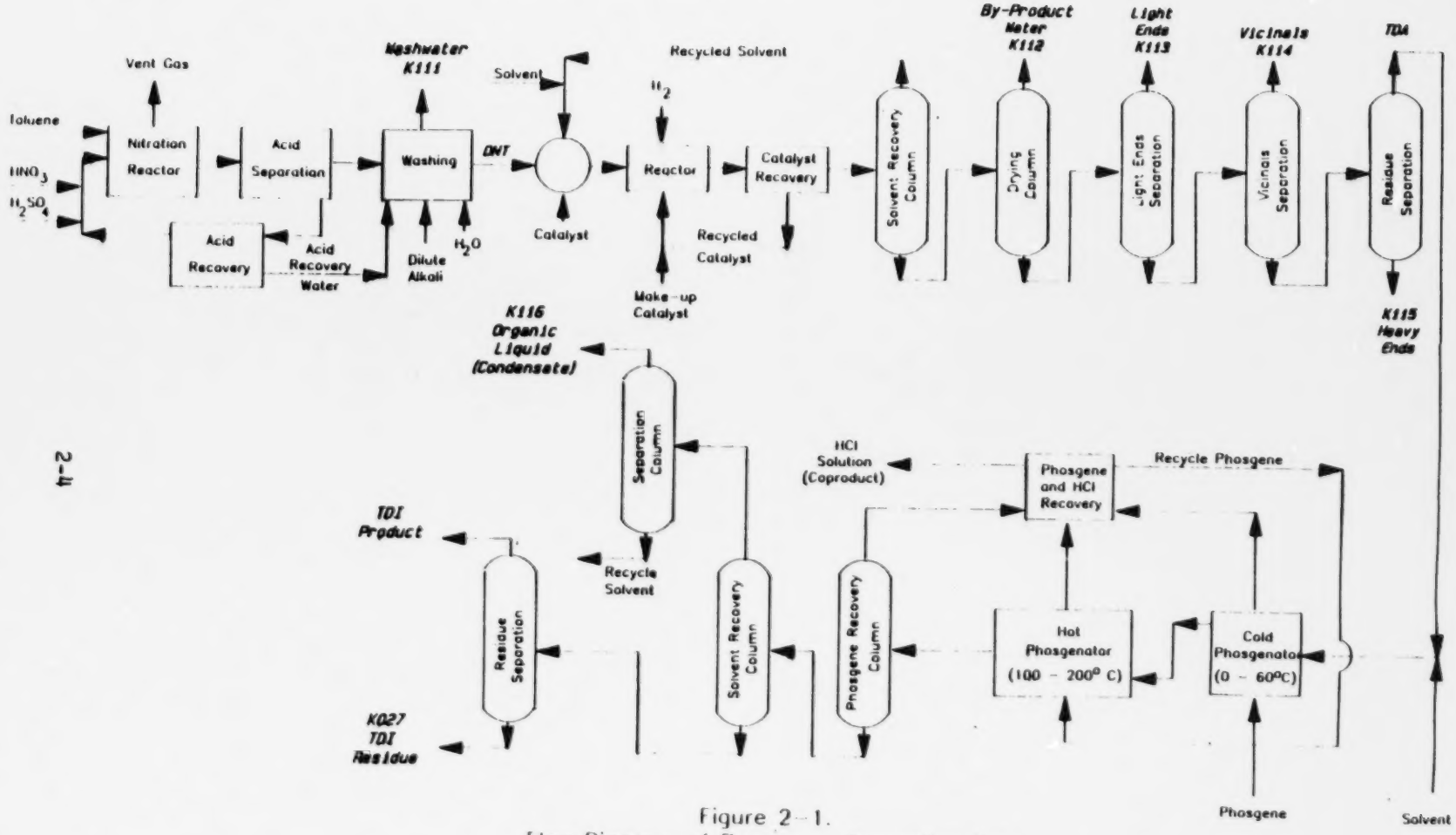

Figure 2-1.
Flow Diagram of Processes Generating the K027, K111 - K116 Waste Codes

The manufacture of toluene diisocyanate (TDI) typically involves three chemical processes: 1. Nitration of toluene to form dinitrotoluene (DNT) 2. Hydrogenation of DNT to form toluenediamine (TDA), and 3. Phosgenation of TDA to form toluene diisocyanate (TDI).

As shown in Figure 2-1, toluene is nitrated with nitric acid in the presence of sulfuric acid, which acts as a solvent and a catalyst. The two-phase product from the nitration reactor is separated into organic and acid layers. Spent acid is then sent to a recovery unit, where the recovered acid solution is recycled to the reactor. Water, a by-product of the nitration reaction, is separated in the acid recovery step and is used in the DNT washing process following acid separation. The organic layer from the acid separation step, which contains the desired product dinitrotoluene (DNT), is purified through a two- or three-stage washing process. Washwaters from the washing process form the listed waste K111.

The DNT product is dissolved in a solvent (typically methanol) and is combined with a catalyst (either palladium on carbon or Raney nickel). The mixture is then sent to a pressurized reactor where hydrogen is introduced. The product from the hydrogenation reaction is sent to a catalyst recovery unit, where the catalyst is recovered. The crude TDA product is then distilled through a series of columns. Solvent is removed from the solvent recovery column and is completely recycled. By-product water resulting from the hydrogenation of dinitrotoluene is removed in the TDA drying column. The by-product water forms the listed waste K112. Light ends are removed from the

light ends separation column and form the listed waste K113. Vicinals (the ortho isomers of TDA) are removed from the vicinals separation column and form the listed waste K114. In the final distillation step, heavy ends are removed from the residue separation column and form the listed waste K115.

Following distillation, the purified TDA is dissolved in a solvent, typically chlorobenzene or o-dichlorobenzene. The resulting mixture is then sent to a series of reactors. Phosgene liquid is fed into the bottom of these reactors, which are referred to as phosgenators. The crude TDI product from the phosgenation reaction is then distilled through a series of columns. Phosgene is recovered in the phosgene recovery column and recycled to the phosgenators. Solvent is removed from the solvent recovery column and sent to a separation column, where the organic liquid condensate (K116) and excess phosgene are separated. The organic condensate from the solvent recovery step forms the listed waste K116. Bottoms from the solvent recovery column are sent to the residue separation column, where TDI residue is separated from the overhead TDI product. The TDI residue forms the listed waste K027.

The wastes listed as U221 (TDA) and U223 (TDI) under Section 261.33 (a) and (d) of the Code of Federal Regulations (CFR) are those materials containing TDA or TDI, intended for disposal, and which meet any of the listing criteria of Section 261.3 CFR. The listing criteria involve a commercial chemical product or manufacturing intermediate which is either reagent grade of the chemical, technical grade, crude product, or a formulation in which the listed chemical (i.e. TDA or TDI) is the sole active ingredient. Technical

grade generally refers to the chemical in various stages of purification. There are no exact criteria, such as percent purity, to define a technical grade of a substance. Also included are off-specification products which, if they met specification, would have the generic name included in 40 CFR 261.33. Therefore, U221 and U223 may be generated from spills, leaks, or discard of chemicals associated with the production of TDA and TDI or from the use of TDA or TDI as an active or additive ingredient in manufacturing processes. To determine if a material or substance that meets these criteria is subject to regulation as a "U" waste, at least one of the following additional criteria must characterize the material. A "U" waste is either: discarded or intended for discard; mixed with another material and applied to the land for dust suppression; applied to the land in lieu of its original intended use; remaining residue that will not be recycled, reclaimed or reused in an original container or liner; used as a fuel additive in lieu of its original purpose or; be contained in soil, water or debris resulting from cleanup of a spill.

While the reaction of amines (TDA) with phosgene is the most common method of manufacturing isocyanates, other processes exist that may produce a TDA or TDI product or manufacturing intermediate. These manufacturing processes may therefore also result in generation of U221 and/or U223 (e.g., an off-spec batch containing TDA or TDI as an active ingredient which cannot be used and must therefore be discarded). U221 and U223 generated by these other processes are subject to the promulgated standards established for wastewater and nonwastewater forms of U221 and U223. Examples of other methods for the production of isocyanates are the Curtius, Hofman, and Lossen Rearrangements,

Metathesis, preparation from isocyanate derivatives, and preparation from isocyanic acid. Facilities that formulate other commercial products such as urethane polymers, foam plastics, or fire retardant materials may also generate U221 and U223 if the unused pure commercial product or intermediate is spilled or intended to be discarded and the TDA or TDI is the manufacturer's commercial product or intermediate having as its sole active ingredient TDI or TDA.

2.2 Waste Characterization

Table 2-2 presents a summary of the publicly available characterization data for K027, K111, K112, K113, K114, K115, and K116. Characterization data are not available for U221 or U223. The summary in Table 2-2 was compiled from data in the Listing Background Document for DNT, TDA, and TDI production, from data based on theoretical calculations, and from patent information supported by unspecified industry data. All available data for each waste code may be found in Appendix A - Confidential Business Information (CBI) Waste Characterization Data. Data listed in this Appendix is located in the confidential portion of the EPA RCRA docket for this rulemaking.

As shown in Table 2-2, K027 contains high levels of TDI and TDA and up to 90% polymers and tar-like materials; K111 and K112 contain <1% organic compounds; K113, K114, and K115 consist of organic waste streams that contain high levels of TDA; and K116 contains high levels of chlorinated hydrocarbons,

Table 2-2

SUMMARY OF PUBLICLY-AVAILABLE WASTE CHARACTERIZATION DATA
FOR WASTE CODES K027, K111, K112, K113, K114, K115, AND K116

Major Constituents	Estimated Untreated Waste Concentration (%)[a]						
	K027	K111	K112	K113	K114	K115	K116
ORGANIC CONSTITUENTS							
BDAT List Constituents							
7. Carbon tetrachloride	--	--	--	--	--	--	0-75
14. Chloroform	--	--	--	--	--	--	0-7
42. Tetrachloroethene	--	--	--	--	--	--	0-15
43. Toluene	--	--	--	--	--	--	CBI
56. Aniline	--	--	CBI	0.01-0.1	0-5	--	--
Non-BDAT List Constituents							
Toluenediisocyanate	0-50	--	--	--	--	--	--
Isocyanates	3	--	--	--	--	--	--
Dinitrotoluenes	--	0-0.3b	--	--	--	--	--
Mononitrotoluenes	--	0.0045	--	--	--	--	--
Dinitrocresols (mostly 2,6-dinitro p-cresol)	--	0.06	--	--	--	--	--
Nitrophenols	--	0.0035	--	--	--	--	--
Nitroaromatics (nitrobenzoic acids and nitrocresols)	--	0.0035	--	--	--	--	--
2,4-TDA & 2,6-TDA	10-50c	--	0.05-0.3	0-37.5	4.5-50	10-50	--
3,4-TDA & 2,3-TDA	--	--	0.05-0.3	0-37.5	40-95	0-2.5	--
o-Toluidine	--	--	0-0.06	0.6-6	0-3	--	
p-Toluidine	--	--	0-0.04	0.4-4	0-2	--	--
Polymers & Tar-Like Materials	90	--	--	--	--	--	--
Phosgene	--	--	--	--	--	--	0-30
Karathane[d]	10-50	--	--	--	--	--	--
Methylcyclohexylamine	--	--	CBI	--	--	--	--
Methylcyclohexanone	--	--	CBI	--	--	--	--

-- = Data are not available for these constituents
CBI = Confidential Business Information
TDA = Toluenediamine

[a] Most of the data shown for K027 and K111-K116 represent analysis for organics using capillary GC/MS Method 8270. One facility reported analysis of K027 using "Total Amine equivalent ASTM Method D-1638".
[b] Includes nitrophenolics.
[c] 2,4-TDA isomer only.
[d] "Karathane" is the common name of the compound "Dinocap."

Table 2-2 (Continued)

SUMMARY OF PUBLICLY-AVAILABLE WASTE CHARACTERIZATION DATA
FOR WASTE CODES K027, K111, K112, K113, K114, K115, AND K116

Major Constituents	Estimated Untreated Waste Concentration (%)[a]						
	K027	K111	K112	K113	K114	K115	K116
INORGANIC CONSTITUENTS							
Water	CBI	CBI	CBI	CBI	--	--	CBI
Ferric chloride	6	--	--	--	--	--	--
Inorganics (H_2SO_4 + HNO_3, Sulfate + Nitrate Salts)	--	1-4	--	--	--	--	--
Spent catalyst (Ni)	--	--	--	--	--	0-5	--
OTHER PARAMETERS							
Ash content (%)	6	--	--	--	--	--	--
Specific gravity	1.22	--	--	--	--	--	--
Heating value (Btu/lb)	6020-9993	--	--	--	--	--	--

-- = Data are not available for these constituents
CBI = Confidential Business Information
TDA = Toluenediamine

[a] Most of the data shown for K027 and K111-K116 represent analysis for organics using capillary GC/MS Method 8270. One facility reported analysis of K027 using "Total Amine equivalent ASTM Method D-1638".
[b] Includes nitrophenolics.
[c] 2,4-TDA isomer only.
[d] "Karathane" is the common name of the compound "Dinocap."

Source: USEPA. Listing Background Document for Dinitrotoluene, Toluenediamine and Toluene Diisocyanate Production. 1985. (10).

including carbon tetrachloride and chloroform. Additionally, based on manufacturing processes generating K027 and K111-K116, these wastes are expected to contain very low concentrations of metals, if any, except K115, which may contain 0-5% spent nickel catalyst. As shown in Table 2-2, K027 has a low ash content of 6 percent. Waste codes K113-K116 are also expected to have low ash contents based on the manufacturing processes generating these wastes.

2.3 Determination of Waste Treatability Groups

EPA's approach to regulating first-third wastes grouped the waste codes into waste treatability groups that were addressed together in developing the BDAT land disposal restrictions. Where EPA believes that wastes represented by different codes can be treated to similar concentrations using identical technologies, the Agency has combined the codes into one treatability group (53 FR 31145, August 17, 1988).

For waste codes K027, K111-K116, U221, and U223, a careful review of waste generation data, waste management practices, and waste characterization data was conducted to determine whether these waste codes could be combined into one or more waste treatability groups. Based on this review, two waste treatability groups have been determined: (1) the K027 and K113-K116, U221, and U223 treatability group (K027 treatability group), and (2) the K111 and K112 treatability group.

K027, K113-K116, U221, and U223, as generated, are usually nonwastewaters containing high concentrations of aromatic organo-nitrogen compounds.

Specifically, the Agency believes that K027 and K113-K116 are expected to contain high concentrations of TDA. In addition to the organo-nitrogen compounds TDA and TDI, K116 is expected to contain high concentrations of chlorinated hydrocarbons, such as carbon tetrachloride and phosgene. K027, K113, K114, and K116 are expected to contain very low concentrations of metals, if any. However, available data show that K115 may contain treatable concentrations of nickel (up to approximately 5%). The Agency has information showing that facilities generating K027 and K113-K116 usually either treat or dispose of these wastes in the same unit or in similar units.

Although EPA lacks characterization data for U221 and U223, the Agency believes that the major organic constituents that will be present in these wastes are TDA in U221 and TDI in U223. Since TDI and TDA products are generated from similar manufacturing processes, EPA believes that any impurities in the commercial products or off-specification products meeting the listing criteria for U221 and U223 will consist of chemicals similar to those typically shown or expected to be contained in K027, K115, and K116. As a result, the Agency expects U221 and U223 to show treatment characteristics similar to K113-K116 and K027. Based on these similarities, the Agency believes that U221 and U223 are amenable to treatment by the same treatment technologies that are applicable to K027 and K113-K116. In fact, available literature (see Reference 27) and current industry practices indicate that U221 and U223 are typically treated by the same processes treating the other K027 treatability group wastes. Therefore, K027, K113-K116, U221, and U223 are considered to represent a single waste treatability group.

K111 and K112 are generated by similar industries (production of nitrated aromatic compounds) and similar processes. These two wastes, as generated, are normally wastewaters containing low concentrations of organic compounds (0-1%). K111 and K112 are expected to contain very low concentrations of metals, if any. K111 and K112 are often co-disposed or co-treated in wastewater treatment systems. Therefore, based on a similarity in waste generation, waste management practices, and waste characteristics, K111 and K112 represent a separate, distinct waste treatability group.

3.0 APPLICABLE AND DEMONSTRATED TREATMENT TECHNOLOGIES

In Section 2.0, the processes generating K027, K111-K116, U221, and U223 were described and characterization data were presented for the wastes. In addition, two treatability groups were identified. This section identifies the treatment technologies that are applicable for treatment of wastes in these treatability groups and determines which of the applicable technologies can be considered demonstrated for the purpose of establishing BDAT.

To be applicable, a technology must theoretically be usable to treat the waste in question or a similar waste. To be demonstrated, the technology must be employed in full-scale operation for the treatment of the waste in question or of a similar waste. Technologies available only at research facilities or at pilot- and bench-scale operations are not considered in identifying demonstrated technologies.

3.1 Applicable Treatment Technologies

The following subsections present applicable treatment technologies for (1) organic constituents in nonwastewater and wastewater forms of K027, K113-K116, U221, and U223, (2) metal constituents in nonwastewater and wastewater forms of K115, and (3) organic constituents in wastewater and nonwastewater forms of K111 and K112. For the purpose of the land disposal restrictions rule, wastewaters are defined as wastes containing less than 1% (weight basis) total suspended solids and less than 1% (weight basis) total organic

carbon (TOC). Wastes not meeting this definition are classified as nonwastewaters.

3.1.1 K027, K113-K116, U221, and U223 Organics

Nonwastewaters

As generated, K027, K113-K116, U221, and U223 are generally nonwastewaters containing high concentrations of aromatic organo-nitrogen compounds. Applicable treatment technologies, therefore, include technologies that destroy or reduce the total amount of various organic compounds in the waste. The Agency has identified incineration, fuel substitution[1], solvent extraction followed by recovery or incineration of the contaminated solvent, and recycle or reuse as potentially applicable for treatment of K027, K113-K116, U221, and U223 nonwastewaters.

The Agency believes that incineration of K027, K113-K116, U221, and U223 will generate low volumes, if any, of ash residue, since the ash content of these wastes is typically low (less than 6% in the case of K027). Treatment (such as filtration) of incineration/fuel substitution scrubber waters may also result in a nonwastewater residual that may be classified as K027, K113-K116, U221, or U223. Since organics are destroyed during incineration,

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[1]Fuel substitutes should meet the criteria discussed in 48 FR 11157-11160.

nonwastewater residues resulting from burning these listed wastes or those generated from filtration of scrubber waters would contain low levels, if any, of organic constituents. Therefore, additional treatment of these residuals would not be required.

Wastewaters

Incineration of K027, K113-K116, U221, and U223 nonwastewaters may result in the generation of scrubber water residuals that may be classified as K027, K113-K116, U221, and U223 wastewaters. Since organics are destroyed during incineration, these scrubber waters would contain low levels, if any, of organic constituents. Therefore, additional treatment of these residuals for hazardous organic constituents would not be required.

Other cases in which wastewater forms of K027, K113-K116, U221, and U223 may be generated include wastewaters in which these codes are mixed with other wastes, wastewaters from containment sumps for storm water or spills, and wastewaters from wash stations for cleaning trucks or equipment. Additionally, the Agency believes that RCRA corrective actions and CERCLA remediations may result in the generation of wastewaters containing K027, K113-K116, U221, and U223 (as either contaminated groundwater, surface water, or treatment residue). These types of wastewaters are "derived from" K027, K113-K116, U221, and U223 and are also subject to the land disposal restrictions. The Agency has identified carbon adsorption followed by regeneration or incineration of the spent carbon, incineration, solvent extraction, and biological treatment,

as potentially applicable for treatment of hazardous organic constituents in these wastewaters. These applicable technologies destroy or reduce the total concentration of hazardous organic compounds in the waste (incineration and biological treatment) or selectively remove hazardous organic compounds from the waste stream (carbon adsorption and solvent extraction).

3.1.2 K115 Metals

Nonwastewaters

As generated, K115 is usually a nonwastewater and may contain 0-5% spent nickel catalyst. Incineration or fuel substitution of K115 nonwastewaters would be expected to generate small amounts of ash that may contain concentrated levels of nickel (since nickel is not destroyed in the combustion process). A nonwastewater residual may also be generated from treatment of incineration/fuel substitution scrubber waters (e.g., spent filter cartridges). The Agency has identified stabilization as a potentially applicable technology for treatment of these K115 nonwastewater residuals.

Wastewaters

Incineration or fuel substitution of K115 nonwastewaters may result in the generation of a scrubber water residual that may be classified as a K115 wastewater. The residual may contain concentrated levels of nickel (since nickel is not destroyed in the combustion process). The Agency has

identified lime and sulfide precipitation followed by vacuum filtration as potentially applicable for treatment of nickel in this K115 wastewater residual.

3.1.3 K111 and K112 Organics

Wastewaters

As generated, K111 and K112 are normally wastewaters containing low concentrations of organic compounds (less than 1%) and very low concentrations of metals. The Agency has identified biological treatment, carbon adsorption, and solvent extraction as potentially applicable for treatment of the organic constituents in these K111 and K112 wastewaters.

Nonwastewaters

All of the treatment processes presented as potentially applicable for organic constituents in K111 and K112 wastewaters generate nonwastewater residuals (e.g., spent biomass, spent carbon, and solvent extract). The Agency has identified fluidized-bed, multiple hearth, or rotary kiln incineration technologies as potentially applicable for treatment of these K111 and K112 nonwastewaters.

3.2 Demonstrated Treatment Technologies

The following subsections present demonstrated treatment technologies for (1) organic constituents in nonwastewater and wastewater forms of K027, K113-K116, U221, and U223, (2) metal constituents in nonwastewater and wastewater forms of K115, and (3) organic constituents in wastewater and nonwastewater forms of K111 and K112.

3.2.1 K027, K113-K116, U221, and U223 Organics

Nonwastewaters

As stated in section 3.1.1, potentially applicable treatment technologies for K027, K113-K116, U221, and U223 nonwastewaters include incineration, fuel substitution, solvent extraction followed by recovery or incineration of the contaminated solvent, and recycle or reuse. The Agency has been unable to identify any facilities using solvent extraction for treatment of these nonwastewaters. One facility recycles K116 nonwastewaters but also occasionally co-incinerates this waste with K027.

Several of the facilities that generate one or more of K027, K113-K116, U221, and U223 incinerate them in liquid injection or fluidized-bed incinerators or burn them in high-temperature boilers on a full-scale level. The Agency is currently aware of three facilities that incinerate these wastes (two on site and one off site) and of at least three facilities that treat these wastes by fuel substitution in high-temperature boilers. (One facility that incinerates K027 also treats one or more of K113-K116 by fuel

substitution, and one facility treats K027 by fuel substitution.) Based on this information, the Agency has determined that incineration and fuel substitution are demonstrated treatment technologies for nonwastewater forms of K027, K113-K116, U221, and U223.

Wastewaters

As stated in Section 3.1.1, potentially applicable treatment technologies for K027, K113-K116, U221, and U223 wastewaters include carbon adsorption followed by regeneration or incineration of the spent carbon, incineration, solvent extraction, and biological treatment. As discussed previously, additional treatment of scrubber waters generated from incineration/fuel substitution is not required. However, other K027-, K113-K116-, U221-, and U223-containing wastewaters may be generated that contain hazardous organic constituents requiring treatment. While the Agency is not aware of any specific facilities that treat wastewater forms of the K027 treatability group, carbon adsorption, solvent extraction, and biological treatment are demonstrated on a full-scale level for treatment of wastes that contain organo-nitrogen compounds (e.g., K103 and K104 wastewaters). Therefore, the Agency believes that since these technologies are demonstrated for treatment of wastes containing similar organic constituents, these technologies are also demonstrated for treatment of wastewater forms of the K027 treatability group. In addition, industry comments indicate that there are facilities that from time to time generate wastewaters contaminated with K027 group wastes and these facilities stated further, that they often treat such wastewaters by

incineration. Therefore, the Agency believes that incineration is also a demonstrated treatment technology for K027, K113-K116, U221, and U223 wastewaters.

3.2.2 K115 Metals

Nonwastewaters

The Agency is not aware of any facilities that treat nickel in K115 nonwastewater residuals using the applicable technology identified in Section 3.1.2. However, EPA has examined its BDAT treatment performance database and determined that stabilization of nonwastewater residuals from incineration and fuel substitution is demonstrated for a similar waste, F006 nonwastewaters. The Agency also believes that none of the constituents present in K115 nonwastewater residuals are likely to interfere with the treatability of nickel because the requirement for thermally destroying organics in K115 will concentrate the concentration of nickel in treated residuals such as ash and incinerator scrubber water. Therefore, the Agency believes that stabilization is demonstrated to treat nickel in K115 nonwastewater residuals.

Wastewaters

The Agency is not aware of any facilities that treat nickel in K115 wastewater. However, EPA has examined its BDAT treatment performance database and determined that lime and sulfide precipitation followed by vacuum

filtration of wastewaters is demonstrated for a similar waste, K062 and metal-bearing characteristic wastes. The Agency also believes that none of the constituents present in K115 scrubber waters are likely to interfere in the treatability of nickel because the requirements for removing the organics in K115 wastewaters will minimize the potential interferences of organics with the treatment of nickel. Therefore, the Agency believes that lime and sulfide precipitation followed by vacuum filtration is demonstrated to treat nickel in K115 wastewaters.

3.2.3 K111 and K112 Organics

Wastewaters

As stated in Section 3.1.3, potentially applicable treatment technologies for K111 and K112 wastewaters include biological treatment, carbon adsorption, and solvent extraction. The Agency has been unable to identify any facilities that currently use solvent extraction to treat either K111 or K112 wastewaters. However, facilities have been identified that treat these wastes by biological treatment or carbon adsorption on a full-scale level. Of the several facilities that generate K111 and/or K112 wastewaters, three facilities currently treat these wastes in biological treatment units, while three facilities use carbon adsorption either alone or as a polishing step prior to disposal. Therefore, the Agency has identified biological treatment and carbon adsorption as the demonstrated treatment technologies for wastewater forms of K111 and K112.

Nonwastewaters

As stated in Section 3.1.3, potentially applicable treatment technologies for K111 and K112 nonwastewaters include fluidized-bed, multiple hearth, or rotary kiln incineration. The Agency is aware of at least one facility that currently treats the nonwastewater residuals derived from the treatment of K111 and K112 by fluidized-bed incineration on a full-scale level. Therefore, the Agency has determined that incineration is the demonstrated treatment technology for nonwastewater forms of K111 and K112.

4.0 TREATMENT PERFORMANCE DATABASE

This section presents the treatment performance data that EPA used to develop BDAT treatment standards for K027, K113-K116, U221, and U223. As discussed previously, the Agency does not have any treatment performance data for the treatment of K027, K113-K116, U221, or U223. However, data are available for treatment of similar wastes and are presented below. The treatment performance data are used in this document to determine which technologies represent BDAT (Section 5.0) and to develop BDAT treatment standards (Section 7.0).

The Agency believes that nickel will be present in treatable concentrations in the wastewater and nonwastewater residuals of treated K115 because metals are not treated by the technologies promulgated for organics in K115. Therefore, treatment performance data were transferred from other previously tested wastes to develop numerical treatment standards for nickel in K115 nonwastewaters and wastewaters. The basis for the data transfer and the sources of treatment performance data are discussed below. For organic constituents in K027, K113-K116, U221, and U223 nonwastewaters and wastewaters, numerical treatment standards cannot be developed because EPA lacks analytical methods that can satisfactorily analyze for the constituents of concern in such complex waste matrices. As a result, EPA chose to specify a method of treatment as the BDAT treatment standard for these wastes. To determine whether the demonstrated technologies identified in Section 3.0 provide substantial treatment for the constituents of concern in K027,

K113-K116, U221, and U223, performance data from treatment of other similar wastes were examined. The data that were examined are presented in this section.

Treatment performance data, to the extent that they are available to EPA, include the concentrations of constituents in the untreated and treated wastes, values of treatment technology operating parameters that were monitored at the time the waste was being treated, values of relevant design parameters for the treatment system, and data on waste characteristics that affect performance of the treatment technology. A discussion of the methodology used to identify treated wastes from which treatment performance data are being transferred is included in Appendix B of this document.

Table 4-1 presents data on waste characteristics that affect performance of the demonstrated treatment technologies, incineration and fuel substitution, for organic constituents in waste codes K027, and K113-K116, (all tables are presented at the end of this section). Available treatment performance data and data for waste characteristics that affect performance of incineration for waste codes K015, K086, and F024 are presented in Tables 4-2 through 4-4, respectively. Table 4-5 summarizes the operating data that correspond to the information presented in Tables 4-1 through 4-4.

Table 4-6 presents available treatment performance data and operating data for carbon adsorption treatment of K103 and K104 wastewaters.

The Agency does not have treatment performance data for biological treatment or incineration of wastewaters that are similar to K027, K113-K116, U221, or U223 wastewaters.

Sources of treatment performance data that demonstrate treatment of nickel, for potential transfer to K115, include those wastes previously tested by stabilization (for nonwastewaters) and by lime and sulfide precipitation followed by vacuum filtration (for wastewaters). EPA presented data for stabilization of metals in nonwastewaters in the California List Notice of Data Availability (52 FR 29992, August 12, 1987). EPA screened these data to determine whether any wastes were generated from similar industries or had similar processing steps or similar waste characteristics as those for ash generated from the incineration of K115.

The Agency has determined that stabilization of wastewater treatment sludge from electroplating operations, F006, is the best source of data for transfer to K115 nonwastewaters (nickel treatment). The F006 stabilization data were chosen since (1) this waste represents a sludge containing high concentrations of nickel, similar to the nickel concentrations (in the percent range) of untreated K115 when compared to other wastes treated by metal stabilization, (2) the numerical standard for nickel in F006 is more conservative than the standard for nickel in other waste codes treated by stabilization (i.e., K062 and metal-bearing characteristic wastes), and (3) the Agency has determined in the past that transfer of data from a sludge to

an ash is technically feasible. In addition, constituents present in K115 nonwastewater-treated residuals are not expected to interfere with the treatment of nickel in K115. Treatment performance data for stabilization of F006 are presented in Table 4-7.

EPA's database for chemical precipitation treatment of wastewaters is included in the California List Notice of Data Availability (52 FR 29992, August 12, 1987). EPA screened these data to determine whether any wastes were generated from similar industries, had similar processing steps, or had similar waste characteristics as those expected for scrubber water generated from the incineration of K115. Data are available for chemical precipitation and vacuum filtration of K062 and metal-bearing characteristic wastes. The K062 and metal-bearing characteristic wastes and K115 scrubber water are both wastewaters and are expected to contain similar concentrations of nickel.

EPA then examined the relative treatability of K115 scrubber water and K062 and metal-bearing characteristic wastes. Waste characteristics that affect treatment performance for chemical precipitation include the concentrations and types of metals in the waste, the concentrations of dissolved solids, the content of oil and grease, and whether the metal exists in the wastewater as a complex. Both wastes are expected to contain the constituent of concern, i.e., nickel. Suspended solids, dissolved solids, and complexed metals are not considered to be significant parameters in either waste. Since K115 scrubber waters are generated from incineration, the presence of oil and grease are not considered to be significant. However, K062 and metal-bearing

characteristic wastewaters contain oil and grease and may therefore be more difficult to treat than K115 scrubber water. In addition, the Agency does not expect any of the constituents present in K115 wastewater treated by carbon adsorption or incineration to interfere with the treatment of nickel in K115.

Based on this analysis, transfer of nickel treatment performance data from K062 and metal-bearing characteristic wastes to K115 wastewaters is valid. Treatment performance data for lime and sulfide precipitation followed by vacuum filtration of K062 and metal-bearing characteristic wastes are presented in Table 4-8.

Table 4-1

WASTE CHARACTERIZATION DATA FOR K027, K113-K116

Waste Characteristics Affecting the Performance of Incineration or Fuel Substitution

Constituents in Untreated Wastes	Concentration in Untreated Waste[a] (ppm)	Boiling Point (°C)	Bond Dissociation Energy (kcal/mole)
K027			
TDI	0-500,000	134	2,350
Polymerized TDI	900,000	NA	NA
2,4-TDA	100,000-500,000	283-285	1,940
Karathane	100,000-500,000	138-140	4,911
K113-K115			
2,4- & 2,6-TDA	0-500,000	283-285	1,940[b]
2,3- & 3,4-TDA	0-950,000	283-285	1,940[b]
o- p-Toluidine[c]	0-100,000	200-202	2,480[b]
Aniline[c]	100-50,000	184-186	1,495
K116			
Phosgene	0-300,000	8.2	335
Carbon tetrachloride	0-750,000	76.7-77	320
Chloroform	0-70,000	61-62	340
Tetrachloroethene	0-150,000	121	465
U221			
TDA	NA	283-285	1,940
U223			
TDI	NA	283-285	2,350

NA = Not available
TDA = Toluenediamine
TDI = Toluene diisocyante

a = From Table 2-2, Section 2.0
c = Constituent in K113 and K114 only
b = Bond dissociation energy for each isomer

Sources: References (22), (23), (24), (25), and (26).

Table 4-2

TREATMENT PERFORMANCE DATA FOR K015: LIQUID INJECTION INCINERATION

Regulated Constituent	Concentration (ppb)[a] Untreated	Concentration (ppb)[a] Scrubber Water[b]	Boiling Point (°C)	Bond Dissociation Energy (kcal/mole)
Anthracene	<5,000	<50-210	242	2,900
Benzal Chloride	910,000-1,100,000	<50-94	205	1,600
Benzo(b and/or k) fluoranthene	<5,000	<50-96	NA	3,990
Phenanthrene	<5,000	<50-58	340	2,900
Toluene	<10	15-59	110.6-111	1,620

a = The operating ranges for the liquid injection incinerator and scrubbing system during the performance test are summarized in Table 4-5.

b = Values have not been adjusted for analytical precision and accuracy.

Source: U.S. EPA, Proposed Best Demonstrated Available Technology (BDAT) Background Document for K015, Volume 1, EPA/530-SW-88-0009-a. (13)

Table 4-3

TREATMENT PERFORMANCE DATA FOR K086: ROTARY KILN INCINERATION

Regulated Constituent	Concentration in Waste (ppm)[a] Untreated	Scrubber Water[b]	Boiling Point (°C)	Bond Dissociation Energy (kcal/mole)
Acetone	CBI	<0.005	56.5	945
Bis(2-ethylhexyl) phthalate	CBI	<0.010	385	6,565
n-Butyl alcohol	+	--	117-118	1,635
Cyclohexanone	CBI	<0.005	155.6	1,685
1,2-Dichlorobenzene	+	--	180.5-181	1,325
Ethyl acetate	**	--	77	1,305
Ethyl benzene	CBI	<0.005	136.3	1,905
Methanol	+	--	64.7	495
Methylene chloride	CBI	<0.005-<0.010	39.75	360
Methyl ethyl ketone	+	--	79.6	1,230
Methyl isobutyl ketone	CBI	--	117-118	1,800
Naphthalene	CBI	<0.010	217.9-218	2,120
Nitrobenzene	+	--	210-211	933
Toluene	CBI	<0.005-<0.010	110.6-111	1,620
1,1,1-Trichloroethane	+	--	74-74.1	625
Trichloroethylene	+	--	86.7-87	485

CBI = Confidential Business Information
+ = Concentration unknown. This constituent was regulated because EPA believes it to be present in the untreated waste.
-- = Treated waste concentration not available.
** = Untreated waste concentration not available.
a = The operating ranges for the rotary kiln incinerator during the performance test are summarized in Table 4-5.
b = Values have not been adjusted for analytical precision and accuracy.

Source: U.S. EPA, Proposed Best Demonstrated Available Technology (BDAT) Background Document for K086, Volume 15, Non CBI Version, EPA/530-SW-88-0009-n. (15)

Footnote: Although a rotary kiln incinerator was used to treat the K086 (solvent wash), the data effectively represents liquid injection because the waste was fed through the liquid injection nozzle on the rotary kiln.

Table 4-4

TREATMENT PERFORMANCE DATA FOR F024: ROTARY KILN INCINERATION

Regulated Constituent	Concentration in Waste (ppm)[a]			Boiling Point (°C)	Bond Dissociation Energy (kcal/mole)
	Untreated Waste	Ash	Scrubber Water		
2-Chloro-1,3-butadiene	<0.5-<200,000	0.10	0.101	59.4	955
3-Chloropropene	<0.5-285,486	0.10	0.101	44-45	810
1,1-Dichloroethane	<0.25-<10,000	<0.005	<0.005	57-57.3	645
1,2-Dichloroethane	<0.25-26,068	0.005	0.005	83-84	645
1,2-Dichloropropane	<0.025-230,000	0.005	0.005	96.4	930
cis-1,3-Dichloropropene	<0.025-160,000	0.005	0.005	108	790
trans-1,3-Dichloropropene	<0.025-290,000	0.005	0.005	112	790
Bis(2-ethylhexyl) phthalate	0.58-<196	0.632-0.666	<0.012-0.014	385	6,465
Di-n-octyl phthalate	<0.351	<0.333-<0.351	<0.0104-<0.0121	385	6,565
Hexachloroethane	<0.351-<196	0.632-0.666	0.012-0.014	186.8-187	565
Pentachlorobenzene	<1.76-<945	<1.67-<1.79	<0.052-<0.061	275-277	1,310
Tetrachlorodibenzofurans	1.6×10^{-7}-0.01	0.00003	0.00001	400-500	1,000
Pentachlorodibenzofurans	2.0×10^{-7}-0.03	0.00003	0.0001	400-500	980
Pentachlorodibenzo-p-dioxins	5.0×10^{-7}-0.002	0.00001	0.00001	400-500	2,490
Hexachlorodibenzofurans	2.7×10^{-7}-0.05	0.00004	0.0003	400-500	960
Hexachlorodibenzo-p-dioxins	5.3×10^{-7}-0.01	0.0001	0.00001	400-500	2,470

[a] = The operating ranges for the rotary kiln incinerator during the performance test are summarized in Table 4-5.

Source: U.S. EPA, Proposed Best Demonstrated and Available (BDAT) Background Document for F024.(12)

Table 4-5

SUMMARY OF OPERATING DATA
FOR INCINERATION OF K015, K086, F024, AND K027

Waste Code:	K027	K027	K015	K086	F024
Type of Incinerators:	Liquid Injection (a)	Fluidized-Bed (b)	Liquid Injection (c)	Rotary Kiln (d)	Rotary Kiln (e)
OPERATING PARAMETERS					
Incineration Chamber					
Temperature (°F)	2,000-2,300	1585.4-1752.8[f]	1,780-2,077	1,880-2,053	1,207-1,604
Feed Rate (lb./min.)	83.3[g]	18.3-30.0	4.14-6.22	NA	NA
Residence Time (sec.)	1.7	NA	NA	0.2[h]	0.1-0.58[h]
Afterburner Chamber					
Temperature (°F)	NA	NA	NA	2,032-2,056	1,877-2,142
Excess oxygen (%)	10-12	7.19-12.24	3.17-5.77[i]	5.0-6.2	5-15
Carbon monoxide (ppm)	75-150	28-255	0-614[i]	3.7-5.0	1-70
Off-Gas Scrubber					
Flow rate (gal./min.)	NA	11-18[j]	17.44	NA	NA
Pressure drop (in. of H_2O)	NA	NA	38-44	NA	NA

(a) Source: Reference 17.
(b) Source: Reference 18.
(c) Source: Reference 13.
(d) Source: Reference 15.
(e) Source: Reference 12.
(f) = This number represents the temperature range measured in the free board area of the fluidized bed incinerator
(g) = This number was calculated using a heating value of 10,000 Btu/lb.
(h) = This number represents the rotational speed of the rotary kiln incinerator in rotations per minute, a surrogate measure of residence time.
(i) = The liquid injection incinerator consists of a single chamber. These parameters were measured in that chamber.
(j) = Make-up flow rate.

NA = Not Available

Table 4-6

TREATMENT PERFORMANCE DATA FOR K103 AND K104:
CARBON ADSORPTION STEP

REGULATED CONSTITUENT	K103 and K104 Concentration (ppm) Untreated	Treated[a]
Aniline	<1.5-<3.0	<0.03-4.20
Benzene	<0.005-0.008	<0.005-0.42
2,4-Dinitrophenol	16-57	0.23-0.38
Nitrobenzene	<3.0-4.5	<0.03-0.15
Phenol	<1.5-<3.0	<0.03-0.15
Cyanides (Total)	1.7-4.77	0.129-0.597

OPERATING PARAMETERS	K103 and K104 Design Value	Operating Range
Feed Rate to the System (lbs/hr)	65,300 (max)	52,200-76,000
Feed pH to the System (standard pH units)	7.0 (min)	3.1-10.6
Feed Temperature to the System (^{o}C)	40	25-44
Total Organic Carbon in Treated Waste (mg/l)	250 (max)	7-79.3
Calculated Residence Time (minutes)	85 (min)	73-107

a = Values have not been adjusted for analytical precision and accuracy.

Source: U.S. EPA, Proposed Best Demonstrated Available Technology (BDAT) Background Document for Aniline Production Treatability Group (K103, K104), Volume 7, EPA/530-SW-88-0009-g.(16)

Table 4-7

TREATMENT PERFORMANCE DATA FOR NICKEL TRANSFERRED FROM STABILIZATION OF F006 NONWASTEWATER

Untreated Waste Concentration		Treated Waste[a] Concentration
Total (mg/kg)	TCLP (mg/l)	TCLP (mg/l)
435	0.71	0.05
989	22.7	0.03
259	1.1	0.27
37	0.52	0.02
701	9.78	0.04
19,400	730	<0.06
13,000	152	0.11
23,700	644	0.04
5,730	16.1	0.02

a = Values have been adjusted for analytical precision and accuracy.

Source: U.S. EPA, Proposed Best Demonstrated Available Technology (BDAT) Background Document for F006, Volume 13, EPA/530-SW-88-0009-1. (11)

Table 4-8

TREATMENT PERFORMANCE DATA FOR NICKEL TRANSFERRED FROM LIME AND SULFIDE PRECIPITATION FOLLOWED BY VACUUM FILTRATION OF K062 AND METAL-BEARING CHARACTERISTIC WASTEWATER

Untreated K062 Waste Concentration (ppm)	Treated K062 Wastewater[a] (ppm)
669	0.36
712	0.33
382	0.39

a = Values have not been corrected for analytical precision and accuracy.

Source: U.S. EPA, Final Best Demonstrated Available Technology (BDAT) Background Document for K062. August 1988. (14)

5.0 IDENTIFICATION OF BEST DEMONSTRATED AVAILABLE TECHNOLOGY (BDAT)

This section presents the Agency's rationale for determining best demonstrated available technology (BDAT) for K027, K113, K114, K115, K116, U221, and U223 nonwastewaters and wastewaters. The Agency's rationale for addressing the K111 and K112 treatability group at a later date is also presented in this section. BDAT is specified for all streams associated with the management of the listed wastes (this pertains to the original waste as well as to any residual waste streams generated by the treatment process).

The Agency determines BDAT based on a review of the available treatment performance data. If data are available for only one treatment technology for a waste, then that technology is "best." If data are available for more than one technology, the data are examined to determine whether one or more of the technologies performs significantly better than the others. All treatment performance data used to determine whether a technology performs significantly better is first corrected for accuracy, as discussed in EPA's Methodology for Developing BDAT Treatment Standards (18).

The technology that performs best on a particular waste or waste treatability group is then evaluated to determine whether it is "available." To be available, the technology must (1) be commercially available, and (2) provide "substantial" treatment of the waste, as determined through an evaluation of treatment performance data. To determine whether treatment is substantial, EPA may consider data on a treatment technology's performance on a

waste similar to the waste in question, provided that the similar waste is at least as difficult to treat. If it is determined that the best technology is not available, then the next best technology is evaluated, and so on.

The determination of BDAT for organics in K027, K113-K116, U221, and U223 is discussed in Section 5.1 for nonwastewaters and in Section 5.2 for wastewaters. The determination of BDAT for nickel in nonwastewater and wastewater forms of K115 is presented in Section 5.3. A summary of BDAT for the K027 treatability group is provided in Section 5.4. The Agency's rationale for addressing the K111 and K112 treatability group at a later date is presented in Section 5.5.

5.1 Determination of BDAT for K027, K113-K116, U221, and U223 Nonwastewater Organics

5.1.1 Identification of BDAT

As discussed in Section 3.2.1, incineration and fuel substitution are demonstrated technologies for treating organics in nonwastewater forms of K027, K113-K116, U221, and U223. The Agency has been unable to identify any other demonstrated technologies for these wastes; therefore, incineration and fuel substitution are the "best" technologies for treatment of organics in K027, K113-K116, U221, and U223 nonwastewaters.

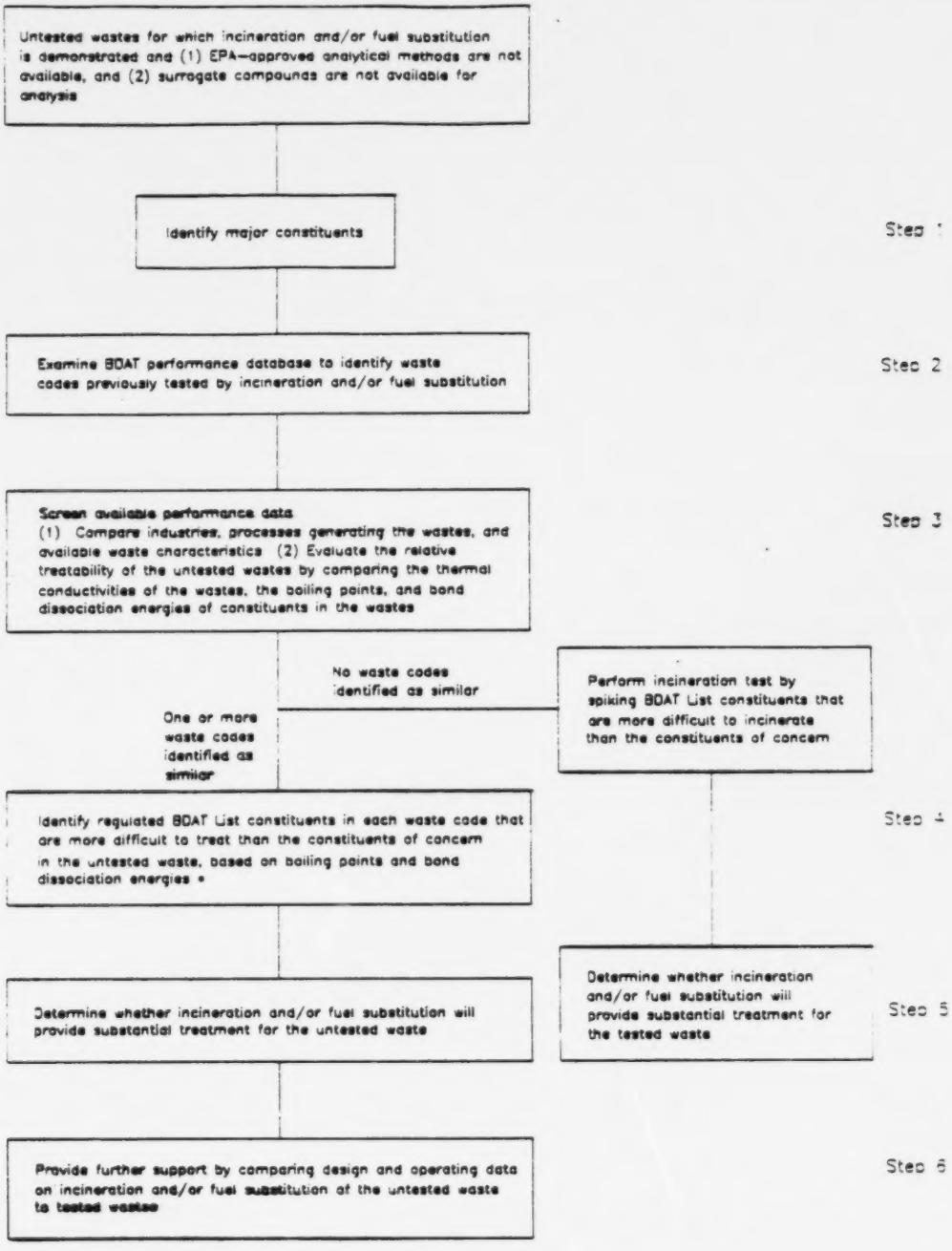
The Agency evaluated these technologies to determine whether they met the two criteria identified above and could therefore be considered "available" for these wastes. The first criterion was satisfied since incineration and fuel substitution are commercially available technologies. The Agency then evaluated available treatment performance data to determine whether incineration and fuel substitution provide substantial treatment of the hazardous organic constituents in K027, K113-K116, U221, and U223. As described below and in Appendix B, incineration and fuel substitution do provide substantial treatment for these wastes and therefore, are available technologies. The Agency has thus determined that incineration and fuel substitution are BDAT for organics in K027, K113-K116, U221, and U223 non-wastewaters.

5.1.2 Evaluation of Substantial Treatment by Incineration and Fuel Substitution

The procedure described in this section and more fully described in Appendix B was used to show that incineration and fuel substitution provide substantial treatment for hazardous organic constituents in K027, K113-K116, U221, and U223. This procedure was used to establish treatment standards as specific technologies rather than concentration-based numerical standards because (1) no analytical methods are available that can satisfactorily analyze for the constituents of concern in these wastes, and (2) surrogate constituents to measure performance have not been identified for the hazardous constituents in these wastes.

Figure 5-1 presents a flowchart illustrating the procedure used to show that incineration and fuel substitution provide substantial treatment for constituents of concern in K027, K113-K116, U221, and U223 nonwastewaters. This procedure is consistent with EPA's methodology for transfer of treatment data from a tested waste to an untested waste to establish treatment standards as concentration-based performance levels. Each step shown in Figure 5-1 is described in Appendix B. The results of these steps for K027, K113-K116, U221, and U223 are discussed briefly below.

Step 1: Available waste characterization data for K027, K113-K116, U221, and U223 were examined to identify "major" constituents of concern. "Major" constituents of concern include but are not limited to those constituents listed in 40 CFR Part 261 Appendix VII and/or VIII at treatable concentrations. For a constituent to be considered at a treatable concentration, it should be shown or believed to be in the waste, should be highly toxic (e.g., dioxins and furans may be present at low concentrations but are still of concern due to their high toxicity), be present in the waste at high concentrations, or is relatively difficult to incinerate (e.g., high boiling points and high bond dissociation energies) than other constituents in the waste. The major constituents of concern for K027 and K113-K116 are shown in Table 4-1. Waste characterization data are not available for U221 and U223; however, these wastes are expected to contain constituents similar to or identical to those listed for K027 and K113-K116 and the major constituents of concern for these wastes are transferred from the listing background document information.


Untested wastes for which incineration and/or fuel substitution is demonstrated and (1) EPA-approved analytical methods are not available, and (2) surrogate compounds are not available for analysis
Identify major constituents
Step 1
Examine BDAT performance database to identify waste codes previously tested by incineration and/or fuel substitution
Step 2
Screen available performance data (1) Compare industries, processes generating the wastes, and available waste characteristics (2) Evaluate the relative treatability of the untested wastes by comparing the thermal conductivities of the wastes, the boiling points, and bond dissociation energies of constituents in the wastes
Step 3
No waste codes identified as similar
Perform incineration test by spiking BDAT List constituents that are more difficult to incinerate than the constituents of concern
One or more waste codes identified as similar
Identify regulated BDAT List constituents in each waste code that are more difficult to treat than the constituents of concern in the untested waste, based on boiling points and bond dissociation energies *
Step 4
Determine whether incineration and/or fuel substitution will provide substantial treatment for the untested waste
Determine whether incineration and/or fuel substitution will provide substantial treatment for the tested waste
Step 5
Provide further support by comparing design and operating data on incineration and/or fuel substitution of the untested waste to tested wastes
Step 6

* Note that regulated constituents are, by definition, substantially treated by the BDAT treatment technology. Substantial treatment is demonstrated by comparing constituent concentrations in the untreated waste with corresponding concentrations in the treatment residuals.

Figure 5-1. Flow Chart Illustrating the Procedure Used to Show Substantial Treatment by Incineration or Fuel Substitution

Step 2: The BDAT treatment performance database was examined to identify all waste codes previously tested by incineration or fuel substitution. The database included only those tests for which the treatment system was well-designed and well-operated during the treatment test and for which substantial treatment of hazardous organic constituents was demonstrated.

Step 3: The tested wastes that were identified in Step 2 were "screened" to identify waste codes that were similar to K027, K113-K116, U221, and U223 or that contain constituents more difficult to treat than those in the untested wastes. Specifically, tested wastes were identified that:

- Were generated from similar industries or similar processes and/or had similar waste characteristics as K027, K113-K116, U221, and U223;
- Had similar or lower thermal conductivities than K027, K113-K116, U221, and U223; and
- Contained regulated BDAT List constituents that were equally or more difficult to incinerate than the constituents of concern in K027, K113-K116, U221, and U223.

The specific tested wastes that met these criteria are K015, K086, and F024.

EPA's BDAT methodology for determining the relative incinerability of a waste includes a comparison of the thermal conductivities of the untested waste with the thermal conductivities of other wastes that have been treatment tested by incinerators or fuel substitution units. EPA's approach is based on the belief that the lower the thermal conductivity of a waste, the harder it is to transfer heat to a constituent in the waste and thus to volatilize and destroy the constituent.

The degree of difficulty of incineration of a particular constituent is based on the boiling point and bond dissociation energy (BDE) of the constituent. The boiling point represents the degree of difficulty associated with volatilization. The lower the boiling point, the easier it is to volatilize the constituent in the incinerator or fuel substitution unit. Once volatilized, a constituent is destroyed by combustion. EPA believes that the energy required to destroy constituents can be assessed through a comparison of each constituent's BDE. Constituents with higher BDE's are more difficult to destroy than are those with lower BDE's. A detailed discussion of EPA's BDAT methodology for determining the relative incinerability of a waste and specific waste constituents is included in the Treatment Technology Background Document (19).

Step 4: Specific constituents that were regulated in the wastes identified in Step 3 that had higher boiling points and bond dissociation energies (and were therefore more difficult to treat) than the constituents of concern in K027, K113-K116, U221, and U223 were identified for each of the tested waste codes. The constituents of concern in K027, K113-K116, U221, and U223 and the corresponding constituents in tested wastes that are more difficult to treat are listed in Table 5-1.

Constituents that have been regulated in the tested codes are substantially treated by incineration, since substantial treatment was a requirement for determination of incineration as BDAT for those wastes. Constituents are considered to be substantially treated if constituent

Table 5-1

COMPARISON OF CONSTITUENTS IN K015, K086, AND F024 THAT ARE MORE DIFFICULT TO TREAT THAN THE CONSTITUENTS OF CONCERN IN K027, K113-K116, U221, AND U223

Constituents of Concern in K027, K113-K116, U221, and U223			Constituents in K015, K086, and F024 That are More Difficult to Treat[a]		
Constituent	Boiling Point, °C	BDE kcal/mole	Constituent	Boiling Point, °C	BDE kcal/mole
1. TDI	134	2,350	Anthracene	242	2,900
			Phenanthrene	340	2,900
			Benzo(b and/or k) fluoranthene	NA	4,030
			Bis(2-ethylhexyl) phthalate	385	6,465
			Di-n-octyl phthalate	385	6,565
			Pentachlorodibenzo-p-dioxin	400-500	2,490
2. TDA	283-285	1,940	Phenanthrene	340	2,900
			Benzo(b and/or k) fluoranthene	NA	4,030
			Bis(2-ethylhexyl) phthalate	385	6,465
			Di-n-octyl phthalate	385	6,565
			Pentachlorodibenzo-p-dioxin	400-500	2,490
			Hexachlorodibenzo-p-dioxin	400-500	2,470

NA = Not available.
BDE = Bond dissociation energy.
TDA = Toluenediamine
TDI = Toluene Diisocyanate

a = The listed constituents are more difficult to treat because they have higher boiling points and higher bond dissociation energies than the constituents of concern in K027, K113-K116, U221, and U223. The listed constituents are substantially treated by incineration and/or fuel substitution.

Table 5-1 (Continued)

COMPARISON OF CONSTITUENTS IN K015, K086, AND F024 THAT ARE MORE DIFFICULT TO TREAT THAN THE CONSTITUENTS OF CONCERN IN K027, K113-K116, U221, AND U223

Constituents of Concern in K027, K113-K116, U221, and U223			Constituents in K015, K086, and F024 That are More Difficult to Treat[a]		
Constituent	Boiling Point, °C	BDE kcal/mole	Constituent	Boiling Point, °C	BDE kcal/mole
3. o- and p- Toluidine	200-202	2,480	Anthracene	242	2,900
			Phenanthrene	340	2,900
			Benzo(b and/or k) fluoranthene	NA	4,030
			Bis(2-ethylhexyl) phthalate	385	6,465
			Di-n-octyl phthalate	385	6,565
			Pentachlorodibenzo-p-dioxin	400-500	2,490
4. Karathane	138-140	4,911	Bis(2-ethylhexyl) phthalate	385	6,465
			Di-n-octyl phthalate	385	6,565

NA = Not available
BDE = Bond dissociation energy.
TDA = Toluenediamine
TDI = Toluene Diisocyanate

a = The listed constituents are more difficult to treat because they have higher boiling points and higher bond dissociation energies than the constituents of concern in K027, K113-K116, U221, and U223. The listed constituents are substantially treated by incineration and/or fuel substitution.

concentrations in the untreated waste are significantly higher than corresponding concentrations in the treatment residuals. If incineration or fuel substitution has been shown to provide substantial treatment in a tested waste for a constituent that is equally or more difficult to treat than a constituent in an untested waste (with respect to thermal conductivity, boiling points, and bond dissociation energies, as described above), then these technologies will also provide substantial treatment of the constituent of concern in the untested waste. EPA also believes that destruction of hazardous organic constituents in a waste is similar whether it occurs in an incinerator, high-temperature boiler, or industrial furnace providing that these treatment technologies are well designed and well operated.

Step 5: As shown in Table 5-1, EPA identified several constituents that were regulated in previously tested waste codes that are more difficult to treat than the constituents of concern in K027, K113-K116, U221, and U223. Therefore, based on the above analyses, EPA believes that incineration and fuel substitution provide substantial treatment of major constituents of concern in K027, K113-K116, U221, and U223, since it was shown in Step 4 that these treatment technologies provided substantial treatment for constituents that were more difficult to treat in similar wastes.

Step 6: In Table 4-5, design and operating data for incineration and/or fuel substitution systems currently treating K027, K113-K116, U221, and/or U223 were compared to design and operating data for treatment systems from the BDAT performance database for the waste codes selected in Step 3. As

shown in the table, the operating ranges for BDAT incineration units (liquid injection for K015, rotary kiln for K086 and F024) on tested waste codes are similar to the operating ranges for the liquid injection and fluidized-bed incineration units treating K027. EPA believes that the similarities in design and operation of incinerators and fuel substitution units treating these wastes provides additional support for the conclusion that incineration and/or fuel substitution provide substantial treatment for K027, K113-K116, U221, and U223 nonwastewaters and therefore are appropriate as BDAT for these wastes.

5.2 Determination of BDAT for K027, K113-K116, U221, and U223 Wastewater Organics

5.2.1 Identification of BDAT

As discussed in Section 3.2.1, carbon adsorption, incineration, solvent extraction, and biological treatment have been identified by the Agency as demonstrated treatment technologies for treating organics in wastewaters similar to K027, K113-K116, U221, and U223. Treatment performance data are available on carbon adsorption for the waste codes K103 and K104. These wastewaters contain cyclic organo-nitrogen compounds at concentrations similar to those expected for K027, K113-K116, U221, and U223 wastewaters. As outlined in Section 5.1.2, the Agency also has treatment performance data for incineration of nonwastewaters that contain constituents harder to incinerate than the constituents of concern in K027, K113-K116, U221, and U223.

Treatment performance data on solvent extraction of K103 and K104 wastewaters represents treatment of wastewaters containing high concentrations of organo-nitrogen compounds. However, since the organo-nitrogen compound concentrations for K103 and K104 are significantly higher than the organo-nitrogen compound concentrations expected in K027 treatability group wastewaters, the Agency does not believe these data can be used to evaluate treatment of K027, K113-K116, U221, and U223 by solvent extraction. The Agency also does not have treatment performance data for biological treatment that can be used to evaluate treatment of K027 treatability group wastes. Therefore, carbon adsorption and incineration are the "best" technologies for treatment of organics in K027, K113-K116, U221, and U223 wastewaters.

The Agency evaluated the carbon adsorption and incineration technologies to determine whether they met the two criteria identified above and could therefore be considered "available" for these wastes. The first criterion was satisfied since carbon adsorption and incineration are commercially available technologies. The Agency then evaluated available treatment performance data to determine whether carbon adsorption and incineration provide substantial treatment of the hazardous organic constituents in K027, K113-K116, U221, and U223. As described in Section 5.1.2 and Appendix B, incineration shows substantial treatment of constituents harder to treat than the constituents of concern in the K027 treatability group. Carbon adsorption will also provide substantial treatment for these wastes and substantial treatment by this technology is discussed below in Section 5.2.2. Therefore, both carbon adsorption and incineration are available technologies. The

Agency has thus determined that carbon adsorption and incineration are BDAT for organics in K027, K113-K116, U221, and U223 wastewaters.

5.2.2 Evaluation of Substantial Treatment by Carbon Adsorption

The information discussed in this section and in Appendix C was used to show that carbon adsorption provides substantial treatment for hazardous organic constituents in K027, K113-K116, U221, and U223 wastewaters. This is necessary because (1) no analytical methods are available that can satisfactorily analyze for the constituents of concern in K027 treatability group, and (2) surrogate constituents to measure performance have not been identified for the hazardous constituents in these wastes.

The Agency evaluated carbon adsorption for substantial treatment by examining the treatment of similar wastes (K103 and K104) by this treatment technology and by evaluating the ability of carbon adsorption to absorb organic constituents similar to those expected in K027, K113-K116, U221, and U223 wastewaters.

The available data for carbon adsorption on wastes similar to K027 treatability group wastes are presented in Table 4-6. The data for K103 and K104 show substantial treatment of wastewaters containing cyclic organonitrogen compounds at concentrations similar to those expected for K027, K113-K116, U221, and U223 wastewaters. Hazardous organic constituents that are expected to be present in K027 treatability group wastewaters are toluene

diisocyanates, toluenediamines, karathane, aniline, tetrachloroethene, chloroform, carbon tetrachloride, o- and p-toluidine, and phosgene. The treatment performance data available for K103 and K104 do not include treatment of any of these constituents; however, since carbon adsorption provides substantial treatment for other organo-nitrogen compounds, the Agency believes that the technology will also provide substantial treatment for the organo-nitrogen compounds expected to be present in K027, K113-K116, U221, and U223 wastewaters.

In addition, carbon adsorption is a commercially available wastewater treatment technology that is commonly used for the removal of organic constituents. Appendix C provides additional information on the ability of carbon absorption to provide substantial treatment for organics in wastewater. Furthermore, the large molecular size, and the complex, branched ring structure of the constituents in K027, K113-K116, U221, and U223 makes them amenable to removal by adsorption on activated carbon. The Agency therefore believes that a properly designed and operated carbon adsorption unit treating K027 group wastes will provide substantial treatment; therefore, carbon adsorption is appropriate as BDAT for these wastes.

5.3 Determination of BDAT for Nickel in K115

Treatment performance data for nickel are transferred from F006 and K062 and metal-bearing characteristic wastes determined by the Agency to be similar to the range of nickel concentrations in untreated nonwastewater and

wastewater forms of K115 respectively. The treatment performance data are presented in Tables 4-7 and 4-8. As discussed in the background documents for F006 and K062, these treatment performance data were reviewed and assessed to determine whether they represented operation of a well-designed and well-operated system, whether sufficient quality assurance/quality control measures were employed to ensure that the detected effluent concentrations were adjusted for analytical precision and accuracy, and whether the appropriate measures of performance were used to assess the performance of the treatment technologies.

Since the Agency does not have data for any other technologies for treatment of nickel in nonwastewaters and wastewaters that are similar to K115, the Agency has determined that stabilization and lime and sulfide precipitation followed by vacuum filtration are the best technologies for K115 nonwastewaters and wastewaters.

The Agency then evaluated the available data to determine whether these technologies are "available." The demonstrated technologies for treatment of nickel in K115--stabilization, and lime and sulfide precipitation followed by vacuum filtration--are commonly used for the treatment of metals in nonwastewaters and wastewaters and are considered to be commercially available. These technologies also provide substantial treatment for nickel. Therefore, stabilization and lime and sulfide precipitation followed by vacuum filtration are "available" for the purpose of establishing BDAT.

Based on the above discussion, EPA is promulgating (1) stabilization as BDAT for nickel in K115 nonwastewaters and (2) lime and sulfide precipitation followed by vacuum filtration as BDAT for nickel in K115 wastewaters.

5.4 Summary of BDAT for the K027 Treatability Group

As discussed in Section 5.1, EPA is promulgating incineration and fuel substitution as BDAT for organics in K027, K113-K116, U221, and U223 nonwastewaters. As discussed in Section 5.2, EPA is promulgating carbon adsorption and incineration as BDAT for the treatment of organic constituents in K027 treatability group wastewaters. EPA is promulgating concentration levels for nickel based on the performance of stabilization as BDAT for nickel in K115 nonwastewaters, and lime and sulfide precipitation followed by vacuum filtration as BDAT for nickel in K115 wastewaters, as discussed in Section 5.3. These BDAT treatment standards do not preclude a facility from using recycling operations in accordance with the conditions specified in 40 CFR Part 261.2.

5.5 Determination of the Regulatory Approach For the K111 and K112 Treatability Group

As described in Section 3.1.3, K111 and K112, as generated, normally consist of wastewater forms and generally contain 0-1% organic compounds. Applicable technologies for treatment of K111 and K112 wastewaters include those that destroy or reduce the total amount of various organic compounds in

the wastes. The following technologies were identified as potentially applicable for treatment of K111 and K112 wastewaters: (1) biological treatment, (2) carbon adsorption, and (3) solvent extraction. The technology identified as potentially applicable for treatment of K111 and K112 nonwastewaters was incineration.

Based on telephone contacts with the eight facilities producing DNT, TDA, and/or TDI, the Agency identified two demonstrated treatment technologies for K111 and K112 wastewaters: biological treatment and carbon adsorption. The Agency also identified fluidized-bed incineration as a demonstrated technology for treatment of sludge derived from wastewater treatment of K111 and K112 where the wastewater treatment sludge is a "derived-from" nonwastewater form of K111 and K112.

To be considered an "available" treatment for K111 and K112, the demonstrated technology must provide substantial treatment in the wastes or similar wastes for constituents of concern. As discussed previously, treatment performance data are not available for biological treatment or carbon adsorption treatment of K111 and K112 wastewaters. Additionally, treatment performance data are not available from other wastes for transfer to the K111 and K112 treatability group. Therefore, at this time the Agency has been unable to show that these technologies provide substantial treatment for constituents of concern in K111 and K112. Thus, EPA is not setting treatment standards for K111 and K112.

Since K111 and K112 were listed after the November 8, 1984 effective date of HSWA and land disposal of these wastes is not subject to either "soft hammer" or "hard hammer" provisions, the Agency believes further study should be made of these wastes and treatment options before proposing BDAT treatment standards.

6.0 SELECTION OF REGULATED CONSTITUENTS

This section presents the rationale for the selection of constituents for regulation in the K027 treatability group. Generally, constituents selected must satisfy the following criteria:

1. The constituent must be on the BDAT List of regulated constituents. (Presence on the BDAT List implies the existence of approved methods for analyzing the constituent in treated waste matrices.)

2. The constituent must be present in, or be suspected of being present in, the untreated waste. For example, in some cases, analytical difficulties (such as masking) may prevent a constituent from being identified in the untreated waste, but its identification in a treatment residual may lead the Agency to conclude that it is present in the untreated waste.

3. Where treatment performance data from other constituents are being transferred, the constituent(s) from which performance data are transferred must be as difficult to treat as the selected constituent(s) being regulated. Assessing ease of treatment varies according to the technology of concern. For instance, factors to consider for incineration include bond dissociation energies, thermal conductivities, and boiling points.

Waste characterization data for the K027 and K113-K116 waste codes were presented in Section 2.0. Major organic constituents of concern in these wastes, such as karathane, TDI, TDA, and o- and p- toluidine, would be considered for regulation; however, these constituents canrot be analyzed due to a lack of satisfactory analytical methods (Section 1.0). As a result, no treatment performance data are available for these constituents (Section 4.0). Therefore, EPA is specifying a treatment technology as the BDAT treatment standard for organics in the K027 treatability group, rather than develop concentration-based treatment performance levels for individual constituents.

Incineration or fuel substitution are the BDAT treatment standard for organics in K027 treatability group nonwastewaters, and carbon adsorption and incineration are the BDAT treatment standard for organics in K027 treatability group wastewaters.

A review of the inorganic waste characterization data identified spent nickel catalyst in untreated K115. Since metals are not treated in either incineration, fuel substitution, or carbon adsorption processes, which are the specified BDAT technologies for the K027 treatability group, the Agency is regulating nickel in nonwastewater and wastewater residuals of K115 based on treatment performance data from other waste codes (Section 4.0).

7.0 CALCULATION OF TREATMENT STANDARDS

The Agency bases treatment standards for constituents on the performance of well-designed and well-operated BDAT treatment systems. These standards must account for analytical limitations in available treatment performance data, and the data must be adjusted for variabilities related to treatment, sampling, and analytical techniques and procedures.

BDAT treatment standards are determined for each constituent by multiplying the arithmetic mean of accuracy-adjusted constituent concentrations detected in treated waste by a "variability factor" specific to each constituent. Variability factors correct for normal variations in the performance of a particular technology over time and are designed to reflect the 99th percentile level of performance that the technology achieves in commercial operation. (The principles of calculating variability factors are described in more detail in EPA's Methodology for Developing BDAT Treatment Standards (18).) Table 7-1 below shows the calculation of treatment standards for nickel in nonwastewaters and wastewater forms of K115.

In cases where EPA has identified a treatment technology for a particular waste or waste treatability group as BDAT, but cannot develop specific concentration-based treatment standards for that waste because of

Table 7-1

CALCULATION OF TREATMENT STANDARDS FOR NICKEL IN K115

NONWASTEWATERS

Regulated Constituents	F006 Constituent From Which Treatment Performance Data Were Transferred	Arithmetic Average of Corrected Treatment Values (ppm)	Variability Factor (VF)	Treatement Standard[a] (Average x VF) (ppm)
Metals				
Nickel	Nickel	0.071	4.47	0.32

Regulated Constituents	K062 Constituent From Which Treatment Performance Data Were Transferred	Arithmetic Average of Corrected Treatment Values (ppm)	Variability Factor (VF)	Treatement Standard[a] (Average x VF) (ppm)
Metals				
Nickel	Nickel	0.387	1.21	0.47

analytical limitations, the Agency can require the use of that treatment technology as the BDAT treatment standard.

For the K027 treatability group, the Agency is promulgating incineration or fuel substitution as the BDAT treatment standard for organics in nonwastewaters, and carbon adsorption and incineration as the BDAT treatment standard for organics in wastewaters. For K115 nonwastewater and wastewater residuals, the Agency is promulgating concentration-based treatment standards for nickel. These standards are shown below.

K115 Nonwastewater Residual
BDAT: Stabilization

	Maximum for any Single Grab Sample	
	Total Composition	TCLP
Constituent	(mg/kg)	(mg/l)
Nickel	Not Applicable	0.32

K115 Wastewater Residual
BDAT: Lime and Sulfide Precipitation followed by Vacuum Filtration

	Maximum for any Single Grab Sample	
	Total Composition	TCLP
Constituent	(mg/l)	(mg/l)
Nickel	0.47	Not Applicable

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Appendix A

CBI WASTE CHARACTERIZATION DATA

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Appendix B

APPLICATION OF THE SECTION 5.1.2 METHODOLOGY TO THE K027 TREATABILITY GROUP

Application of the Section 5.1.2 Methodology to the K027 Treatability Group

The methodology outlined in Section 5.1.2 was applied to the K027 treatability group to show that incineration and/or fuel substitution will provide substantial treatment of the hazardous constituents in nonwastewater forms of K027, K113-K116, U221, and U223. Each step, shown in the flowchart of Figure 5-1 and described in Section 5.1.2, is repeated below along with results of its application to the K027 treatability group.

Step 1: Examine available waste characterization data for K027 and K113-K116 and identify major constituents of concern.

Characterization data for K027 and K111-K116 are presented in Table 2-2 of Section 2.0. Many of the constituents that characterize these waste codes are not on the BDAT List of hazardous constituents because of the difficulties associated with analyzing for the constituents in complex waste matrices (as discussed in Section 1.0). However, these constituents are major constituents of concern for the K027 waste treatability group, as discussed below.

Major constituents of concern include but are not limited to those constituents listed in 40 CFR Part 261 Appendix VII and/or VIII at treatable concentrations. For a constituent to be considered at a treatable concentration, it should be shown or believed to be in the waste, should be highly toxic (e.g., dioxins and furans may be present at low concentrations but are

still of concern due to their high toxicity), be present at high concentrations in the untreated wastes, and/or has a high degree of difficulty for treatment. EPA's BDAT methodology for determining the relative difficulty in incineration of different hazardous constituents includes a comparison of the boiling points and bond dissociation energies of the constituents. As shown in Table 2-2, karathane, TDI, TDA, and carbon tetrachloride are present in the untreated wastes at the highest concentrations. In addition, karathane, TDI, and o- and p-toluidine have the highest bond dissociation energies of the constituents present in the untreated wastes (4,911 kcal/mole; 2,350 kcal/mole; and 2,480 kcal/mole, respectively). 2,4-TDA and 2,6-TDA also have the highest boiling points (283-285°C). Therefore, based on their high toxicities, high concentrations in the untreated wastes, and high degrees of difficulty to incinerate, the following constituents have been identified as the major constituents of concern for the K027 waste treatability group: karathane, TDI, 2,4- and 2,6-TDA, and o- and p-toluidine.

Step 2: Examine the BDAT performance database to identify all waste codes previously tested by incineration processes (e.g., incineration and/or fuel substitution).

As discussed in Section 5.0 (Step 2), the BDAT incineration database was selected for examination in this methodology. This incineration database consists of performance data obtained from 12 incineration treatment tests performed by the BDAT program. The incineration database includes both treatment performance data (concentrations of hazardous constituents detected

in the untreated and treated wastes) and corresponding design and operating data for the incineration systems.

For the BDAT program, incineration tests were performed only on incinerators operating under 40 CFR Part 264 Subpart O or 40 CFR Part 265 Subpart O, or on fuel substitution units operating under 40 CFR Part 266. Subsequent to each treatment test, EPA performed an engineering analysis of the treatment system's operation during the treatment test to determine whether the treatment system was well-designed and well-operated. The determination of whether a treatment system was well-designed and well-operated was based on whether the treatment system was operating within design operating parameters during the treatment test. Additionally, EPA reviewed the performance data to determine whether the treatment system provided substantial treatment for the constituents of concern (i.e., regulated constituents) in the tested waste. If the treatment was determined to be well-designed and well-operated and substantial treatment was shown, the Agency included the data in the development of treatment standards for the tested waste. In cases where the treatment system was determined to be poorly-designed or poorly-operated, the Agency excluded that performance data from the incineration database, precluding the use of that data in the development of treatment standards.

Based on a review of the existing BDAT performance database, the waste codes previously tested by incineration were identified and are shown on Table B-1.

Table B-1

WASTE CODES PREVIOUSLY TESTED BY INCINERATION

Waste Code	Definition in 40 CFR Part 261	Type of Incineration Test
K001	Bottom sediment sludge from the treatment of wastewaters from wood preserving processes that use creosote and/or pentachlorophenol	Rotary kiln
K015	Still bottoms from the distillation of benzyl chloride	Liquid injection
K019	Heavy ends from the distillation of ethylene dichloride in ethylene dichloride production	Rotary kiln
K024	Distillation bottoms from the production of phthalic anhydride from naphthalene	Rotary kiln
K037	Wastewater treatment sludge from the production of disulfoton	Rotary kiln
K048	Dissolved air flotation (DAF) float from the petroleum refining industry	Fluidized-bed
K051	API separator sludge from the petroleum refining industry	Fluidized-bed
K086	Solvent washes and sludges, caustic washes and sludges, or water washes and sludges from cleaning tubs and equipment used in the formulation of ink from pigments, driers, soaps, and stabilizers containing chromium and lead	Rotary kiln
K087	Decanter tank tar sludge from coking operations	Rotary kiln
K101	Distillation tar residues from the distillation of aniline-based compounds in the production of veterinary pharmaceuticals from arsenic or organo-arsenic compounds	Rotary kiln
K102	Residue from the use of activated carbon for decolorization in the production of veterinary pharmaceuticals from arsenic or organo-arsenic compounds	Rotary kiln

Table B-1 (Continued)

WASTE CODES PREVIOUSLY TESTED BY INCINERATION

Waste Codes	Definition in 40 CFR Part 261	Type of Incineration Test
F024	Wastes, including but not limited, distillation residues, heavy ends, tars, and reactor clean-out wastes, having carbon content from one to five, utilizing free radical catalyzed processes (this listing does not include light ends, spent filters, and filter aids, spent dessicant, wastewater, wastewater treatment sludges, spent catalysts, and wastes listed in Section 261.32)	Rotary kiln

Step 3: Screen the BDAT incineration database and identify waste codes that meet the criteria (a-c) described below.

(a) Identify wastes that are generated from similar industries or similar processes, and/or have similar waste characteristics as K027, K113-K116, U221, and U223.

K027, K113-K116, U221, and U223 are generated from the production of organic chemicals; specifically, from the production of toluene diisocyanate and/or toluenediamine. Of the wastes previously tested by incineration, K015, K019, K024, K037, K086, and F024 were identified as waste codes also generated from the production of organic chemicals. None of these wastes were generated from similar processes as K027, K113-K116, U221, or U223, however, these wastes previously tested by the Agency show the presence of organic constituents that are as difficult to treat as those organic constituents in K027, K113-K116, U221, and U223.

(b) Identify wastes that have similar or lower thermal conductivities than the untested wastes of concern.

Analytical determinations of the thermal conductivities for these wastes are not currently available; however, the relative thermal conductivities of the wastes can be compared based on the chemical characteristics of these wastes. In general, organic constituents have similar thermal conductivities. Solids tend to have higher thermal conductivities than liquids.

Metals have a high thermal conductivity, whereas inorganics, which are non-metallic, generally act as insulators and have low thermal conductivities.

The wastes K015, K019, K024, K027, K037, K086, K113-K116, and F024, are generated from the production of organic chemicals; therefore, these wastes are expected to have high concentrations of organic constituents and very low concentrations, if any, of metals. K086 treated in EPA's incineration test consisted of liquid wastes. All other waste streams are expected to be solid or semi-solid waste mixtures. Based on the discussion above, K086 as a liquid is expected to have a lower thermal conductivity (i.e., be more difficult to incinerate) than K027, K113-K116, U221, and U223. The other waste streams, K015, K019, K024, K037, and F024, are expected to have similar thermal conductivities (i.e., similar incinerability) as K027, K113-K116, U221, and U223.

(c) Identify wastes that contain regulated BDAT List constituents that are equally or more difficult to incinerate than the constituents of concern.

The boiling points and bond dissociation energies (BDE's) of regulated BDAT List constituents in K015, K019, K024, K037, K086, and F024 were examined. Of these wastes, K015, K086, and F024 were identified as the waste codes that contained regulated BDAT List constituents that were more difficult to incinerate (i.e., had higher BDE's and boiling points), than K027, K113-K116, U221, and U223 constituents of concern. Characteristics of the

regulated constituents in K015, K086, and F024, along with the performance data, if available, are summarized in Tables 4-2 through 4-5 of Section 4.0.

Step 4: Select constituents from waste codes identified in Step 3 that meet the criteria delineated below.

The waste codes identified in Step 3 are K015, K086, and F024. Characteristics of the constituents of concern in the K027, K113-K116, U221, and U223 treatability group are summarized in Table 4-1 of Section 4.0. Characteristics of the regulated BDAT List constituents in and treatment performance data from K015, K086, and F024 were examined to identify constituents that:

(a) Have higher boiling points and bond dissociation energies than the constituents of concern in K027 and K113-K116.

As mentioned in Step 1, the constituents of concern in K027 and K113-K116 are TDI, TDA, o- and p-toluidine, and karathane.

Based on the waste characterization and performance data presented in Tables 4-2 and 4-5 of Section 4.0, anthracene, phenanthrene, and benzo(b and/or k)fluoranthene in K015 were identified as constituents that have higher bond dissociation energies than TDI, TDA, and o- and p-toluidine. In addition, phenanthrene has a higher boiling point than TDI, TDA, and o- and p-toluidine. Anthracene has a higher boiling point than karathane, TDI, and

o- and p-toluidine, but a lower boiling point (bp 242°C) than TDA (bp 283-285°C). A boiling point is not available for benzo(b and/or k)fluoranthene. However, based on its structure, benzo(b and/or k)fluoranthene is expected to have a higher boiling point than phenanthrene. Therefore, benzo(b and/or k)fluoranthene is expected to have a higher boiling point than TDI, TDA, and o- and p-toluidine.

Based on waste characterization and performance data presented in Tables 4-3 and 4-5 of Section 4.0, bis(2-ethylhexyl)phthalate was identified as the only regulated constituent in K086 that has a higher bond dissociation energy than either karathane, TDI, TDA, or o- and p-toluidine. In addition, the boiling point for bis(2-ethylhexyl)phthalate is also higher than the boiling points for the K027 treatability group's constituents of concern.

Based on waste characterization and performance data presented in Tables 4-4 and 4-5 of Section 4.0, bis(2-ethylhexyl)phthalate, di-n-octyl phthalate, pentachloro-dibenzo-p-dioxin, and hexachloro-dibenzo-p-dioxin in F024 were identified as constituents that have higher bond dissociation energies (BDE's) than either TDI, TDA, o- and p-toluidine or karathane. (Bis(2-ethylhexyl)phthalate and di-n-octyl phthalate have higher BDE's than all four constituents of concern in the K027 treatability group; pentachloro-dibenzo-p-dioxin has a BDE higher than TDI, TDA, and o- and p-toluidine; and hexachloro-dibenzo-p-dioxin has a higher BDE than TDA.) In addition, the four constituents identified in F024 all have higher boiling points than karathane, TDI, TDA, and o- and p-toluidine in the K027 treatability group.

(b) Are present in the untreated wastes at concentrations high enough to allow a determination that substantial treatment was achieved in the treated waste.

As shown in Tables 4-2 through 4-4, the selected constituents anthracene, phenanthrene, benzo(b and/or k)fluoranthene, bis(2-ethylhexyl)-phthalate, di-n-octyl phthalate, pentachloro-dibenzo-p-dioxin, and hexachloro-dibenzo-p-dioxin were all present in the untreated wastes at concentrations high enough to allow determination that substantial treatment was achieved in the treated waste.

Step 5: Summarize demonstration of substantial treatment.

The constituents identified in Step 4, along with their characteristics and the corresponding constituents of concern in the K027, K113-K116, U221, and U223 treatability group, are summarized below.

As discussed earlier, EPA's BDAT methodology for determining the relative difficulty of incineration of different hazardous constituents involves the comparison of boiling points and bond dissociation energies of the hazardous constituents. EPA's approach is based on the belief that the higher the boiling point, the harder it is to volatilize the constituent; the higher the bond dissociation energy, the harder it is to destabilize the constituent. Therefore, based on the above information, anthracene, phenanthrene, benzo(b and/or k)fluoranthene, bis(2-ethylhexyl)phthalate, di-n-octyl

phthalate, and pentachlorodibenzo-p-dioxin are shown to be more difficult to combust than TDI and o- and p-toluidine. Phenanthrene, benzo(b and/or k)-fluoranthene, bis(2-ethylhexyl)phthalate, di-n-octyl phthalate, pentachlorodibenzo-p-dioxin, and hexachlorodibenzo-p-dioxin are shown to be more difficult to combust than TDA and bis(2-ethylhexyl)phthalate, and di-n-octyl phthalate is shown to be more difficult to combust than karathane.

Furthermore, performance data from incineration of these constituents show that they are substantially treated by incineration. Therefore, since substantial treatment is demonstrated by incineration for constituents that are more difficult to incinerate than TDI, TDA, karathane, and o- and p-toluidine, combustion (as incineration and/or fuel substitution) is expected to provide substantial treatment for these major constituents of concern in the K027 treatability group.

In summary, the above analyses demonstrate that incineration provides substantial treatment for K027, K113-K116, U221, and U223 and, therefore, support the determination to identify incineration and fuel substitution as the BDAT method of treatment for K027, K113-K116, U221, and U223.

Step 6: Compare design and operating data for incineration systems treating K015, K086, K027, K113-K116, and F024.

To further support the determination of incineration as the BDAT method of treatment for K027, K113-K116, U221, and U223, EPA compared design

and operating data for incineration systems treating K015, K086, F024, K027, and K113-K116. Table 4-5 in Section 4.0 summarizes available operating ranges for incineration systems treating K027, K015, K086, and F024. Although operating conditions vary from facility to facility and are waste-specific, the operating ranges for the incinerator treating K027 are very similar to the operating ranges for incinerators treating K015, K086, and F024, as indicated in Table 4-5. Therefore, based on the similarity in operating ranges of these incinerators, and since the incinerators treating K015, K086, and F024 have been shown to provide substantial treatment of hazardous organic constituents, it is expected that incineration systems with similar operating conditions also provide substantial treatment for K027, K113-K116, U221, and U223.

Appendix C

CARBON ADSORPTION FOR THE TREATMENT OF K027 TREATABILITY GROUP WASTEWATERS

Carbon Adsorption for the Treatment of K027 Treatability Group Wastewaters

The information presented in Section 5.2.2 was applied to the K027 treatability group to show that carbon adsorption will provide substantial treatment of the hazardous organic constituents in wastewater forms of K027, K113-K116, U221, and U223. The information presented below documents the ability of a well-designed and well-operated carbon adsorption unit to substantially treat organics in K027 treatability group wastewaters. This information is presented in sections that describe the underlying principles of carbon adsorption treatment, the waste characteristics affecting performance, and the design and operating parameters that can be used to define a well-designed and well-operated carbon adsorption unit.

C.1 Underlying Principles of Carbon Adsorption

Activated carbon treatment is an application of the principle of adsorption, where adsorption is the mass transfer of a molecule from a liquid or gas into a solid surface. Adsorption with activated carbon is an important separation method for removing organics from liquids. It occurs when the surface of the activated carbon attracts the ions or molecules of the organic solid to form a layer on the carbon surface and accumulate in its pores.

Activated carbon is manufactured to produce extremely porous carbon particles, with an internal surface area that is very large (500 to 1400 square meters per gram of carbon). This porous structure, through chemical and physical forces, attracts and holds (adsorbs) organic molecules as well as

certain inorganic molecules. It is not unusual for activated carbon to adsorb from aqueous solution 0.15 grams of an organic contaminant per gram of carbon, though 0.10 gram/gram is probably a more realistic general estimate. The principal factor that affects carbon adsorption is the chemical affinity between the carbon and the organic compound. Other characteristics, such as solubility, temperature, pH, type of activated carbon used, presence of other organics, and contact time also influence the effectiveness of carbon adsorption.

Once contaminants of concern have been removed from K027 treatability group waste streams onto the carbon, two options are available. The activated carbon can (1) be disposed of by incineration in a well-designed, well-operated incinerator, as regulated under 40 CFR Part 264 Subpart O and Part 265 Subpart O, or (2) be regenerated for further use through thermal methods by a hazardous-waste permitted regenerator facility. However, nonwastewater treatment residuals resulting from the thermal regeneration units must comply with the nonwastewater standard promulgated unless the thermal regeneration unit is already regulated under 40 CFR 264 Subpart O, 265 Subpart O, or 266 Subpart D.

C.2 Waste Characteristics Affecting Performance

The waste characteristics that affect an activated carbon system's performance are: the types of organic contaminants, the concentrations of contaminants, and the concentrations of suspended solids, grease and oil.

C.2.1 Types of Organic Contaminants

All organic molecules can be adsorbed by activated carbon to some degree. Generally, adsorption will increase with molecular weight until the particle size becomes too large for carbon pore size. Activated carbon usually has a greater affinity for aromatic compounds than for straight chain compounds. Nonpolar compounds are usually easily adsorbed, whereas polar ones are not. Halogenated organic compounds (HOCs), if aromatic (such as PCBs), are readily absorbed. Finally, it has been demonstrated in practice that adsorption will increase with decreasing solubility.

Table C-1 presents the constituents of concern for K027, K113-K116, U221, and U223, along with some of their waste characteristics. As seen in Table C-1, all of the constituents of concern are organic compounds with high molecular weights, and most of the constituents of concern are either aromatic compounds or nonpolar compounds.

For these reasons, the Agency believes that carbon adsorption can provide substantial treatment of the constituents of concern in K027, K113-K116, U221, and U223.

C.2.2 Concentrations of Contaminants

The process of carbon adsorption becomes ineffective at concentrations exceeding a few thousand mg/l (ppm). The carbon adsorbs concentrated

Table C-1

CONSTITUENT CHARACTERISTICS OF K027, K113-K116, U221, AND U223

Constituent of Concern	Molecular Weight	Aromatic Compound	Halogenated Organic Compound	Non-Polar
Toluene diisocyante	174	Yes	No	*
Toluenediamine	122	Yes	No	*
Karathane	364	Yes	No	*
Aniline	93	Yes	No	*
Tetrachloroethene	166	No	Yes	Yes
Chloroform	119	No	Yes	Yes
Carbon tetrachloride	154	No	Yes	Yes
Toluidine	107	Yes	No	*
Phosgene	99	No	Yes	Yes

* Polar-covalent molecules.

contaminants so quickly that carbon consumption becomes excessive, and frequent disposal and/or regeneration of carbon becomes a greater problem than removal of the organic materials from the waste stream. In the case of K027 treatability group wastes, the wastewater forms are expected to contain contaminants of concern at ppm concentrations. Therefore, the concentrations in these wastes are expected to be well within the limits of the carbon adsorption process, thereby supporting the ability of this treatment method to provide substantial treatment of these wastes.

C.2.3 Concentrations of Suspended Solids, Grease, and Oil

Depending on the type of carbon adsorption system used, suspended solids, oil, and grease may eventually plug, bind, or coat the activated carbon so that it can no longer sustain the flow of wastewater. Wastewaters which contain high amounts of total suspended solids, oil and/or grease may therefore require pretreatment or prefilter operations prior to carbon adsorption treatment. In the case of the K027 treatability group, suspended solids may be of concern in some of the wastewaters generated. The Agency therefore recommends that a well-designed carbon adsorption system may include a prefilter to filter out the suspended solids. This nonwastewater residue would then be considered a "derived from" K027, K113-K116, U221, or U223, and would require incineration in a well-designed and well-operated thermal treatment unit (regulated under 40 CFR Part 264 Subpart O or Part 265 Subpart O) prior to land disposal.

C.3 Design and Operating Parameters

C.3.1 Design Parameters

Two types of carbon adsorption systems in general use are the powdered activated carbon (PAC) system and the nonfluidized granular-activated carbon (GAC) system. In the PAC system, the incoming waste stream is thoroughly stirred with the PAC, and after adsorption equilibrium is reached, the mixture is settled or filtered to separate the PAC from the wastewater. In GAC systems, the carbon is packed in columns and the liquid is passed through the bed of carbon. The type of system to use depends on the waste stream to be treated. In addition, the design must account for three parameters that affect the ability of activated carbon to adsorb contaminants: contact time, carbon particle type and size, and wastewater flow rate.

Contact Time

For both PAC and GAC systems, contact time must be determined by testing individual wastes with different activated carbon samples. Once contact time is determined for adequate removal of contaminants, tank sizing is the next step and will depend on the waste flow rate.

Carbon Particle Type and Size

Activated carbon is made from a variety of substances (e.g., coal or wood), ground to many different sizes, and manufactured with "customized" pore

sizes. A range of surface areas and individual pore sizes will determine the carbon's adsorptive capacity. Bench testing is recommended to determine the most effective activated carbon product for a particular waste stream and desired effluent.

Wastewater Flow Rate

GAC systems are designed for upflow or downflow operation. For both types, there are practical limits to the liquid velocity. Once the velocity and contact time are determined, the bed cross-section and depth are sized to meet these requirements.

C.3.2 Operating Parameters

A number of parameters must be maintained during operation of a carbon adsorption unit to ensure that the adsorption system adheres to the design specifications. These parameters are: waste liquid concentration, temperature, pH, suspended solids and oils, and contact time.

Waste Liquid Concentration

In GAC systems, the waste liquid concentration has a direct effect on the operation of an adsorption system because if the concentration is significantly higher than the design concentration, column breakthrough will occur quickly, and excessive regeneration will be required. Conversely, if